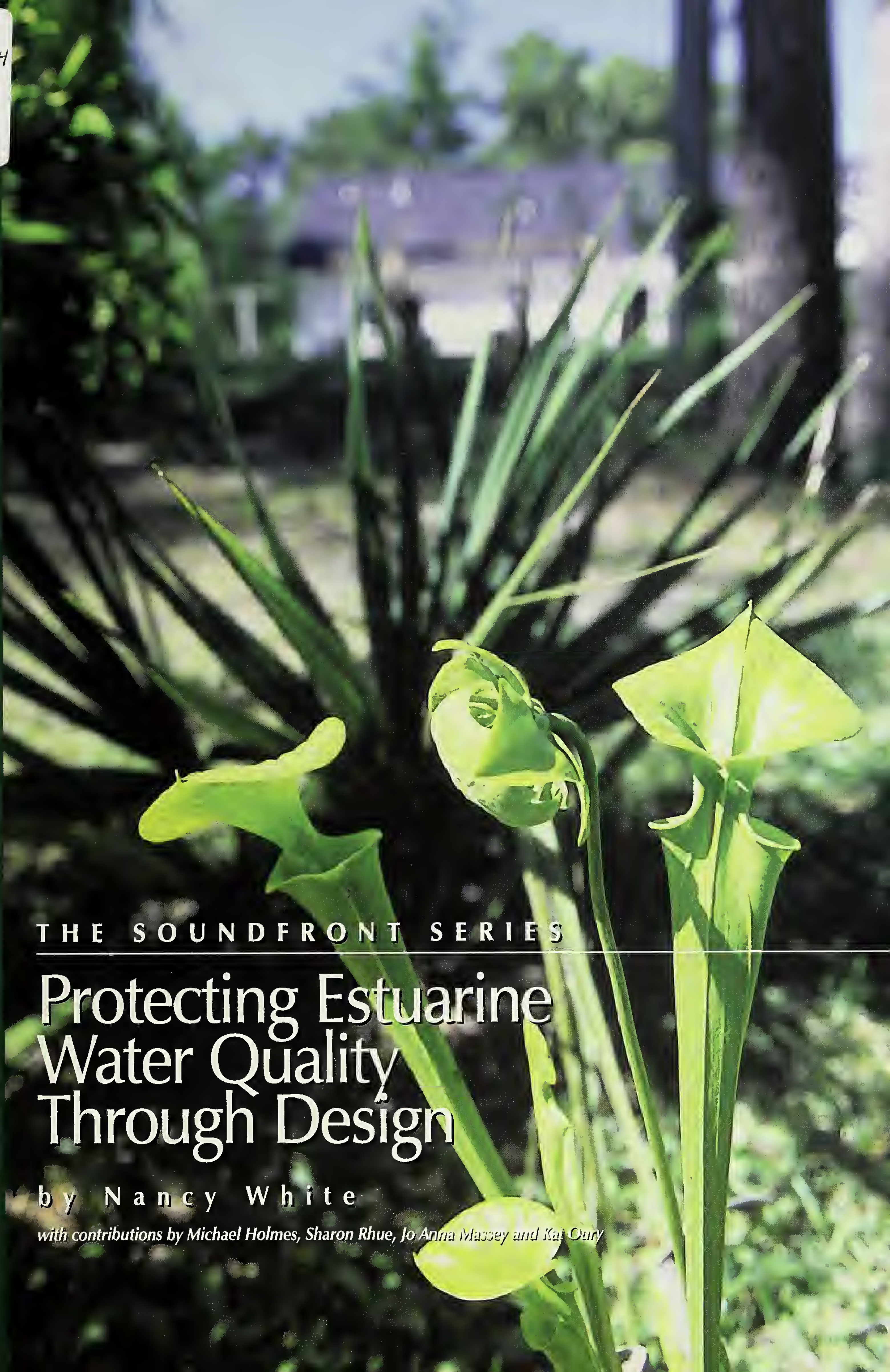


THE SOUNDFRONT SERIES

Protecting Estuarine Water Quality Through Design

by Nancy White

with contributions by Michael Holmes, Sharon Rhue, Jo Anna Massey and Kat Oury

PREFACE

The estuarine areas of North Carolina are seeing increased residential and commercial development, with more proposals on the horizon. Sustainable use of these areas requires awareness, understanding and implementation of sound design and management options. The long-term environmental health of the land, water and natural resources will benefit the growing economy and quality of life.

The N.C. Division of Coastal Management with North Carolina Sea Grant and the North Carolina State University College of Design developed *The Soundfront Series*, informational guides to assist property owners and community planners and managers. The guides are available in print and on the Web.

The series includes:

• *Shoreline Erosion in North Carolina Estuaries*, by Stanley R. Riggs. UNC-SG-01-11.
Riggs is a distinguished professor of geology at East Carolina University.

• *Managing Erosion on Estuarine Shorelines*, by Spencer Rogers and Tracy E. Skrabal. UNC-SG-01-12.
Rogers is North Carolina Sea Grant's coastal erosion and construction specialist.
Skrabal is a senior scientist with the North Carolina Coastal Federation.

• *Protecting Estuarine Water Quality Through Design*, by Nancy White. UNC-SG-01-13.
White is a research associate professor of landscape architecture in the College of Design at North Carolina State University.

• *Protecting the Estuarine Region Through Policy and Management*, by Walter Clark. UNC-SG-01-14.
Clark is North Carolina Sea Grant's coastal law and policy specialist.

Lundie Spence, marine education specialist for North Carolina Sea Grant, and Bill Crowell and Michael J. Lopazanski of the Division of Coastal Management, served as coordinators and technical editors for the series. Katie Mosher, Ann Green and Pam Smith, all of the North Carolina Sea Grant communications team, edited the series.

For information on the Division of Coastal Management, call 919/733-2293 or 888-4RCOAST. The division's Web site includes information on permits and regulations, as well as contacts for regional offices. Go to *www.nccoastalmanagement.net*.

For information on North Carolina Sea Grant — and to order individual guides or the complete series — call 919/515-2454. Online, go to *www.ncsu.edu/seagrant*.

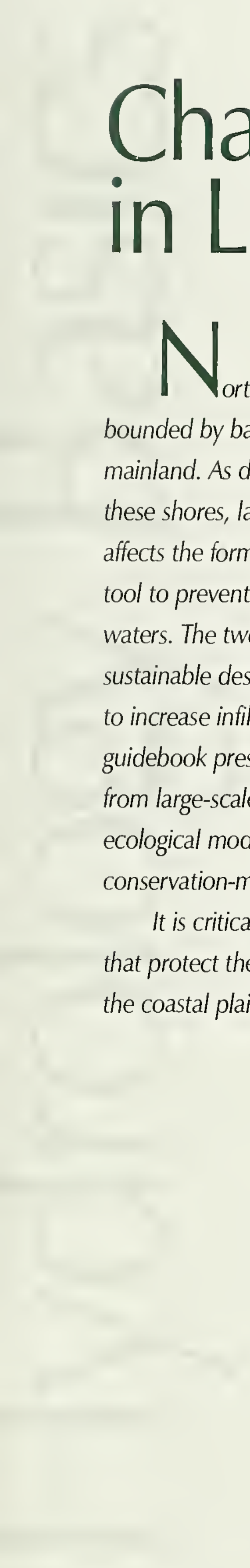
TABLE OF CONTENTS

Protecting Estuarine Water Quality Through Design

Chapter 1: Hydrology Basics in Land Planning

North Carolina's estuaries are bounded by barrier islands and the mainland. As development increases on these shores, landscape design, which affects the form of development, can be a tool to prevent impairment of estuarine waters. The two over-riding goals of sustainable design are to reduce runoff and to increase infiltration of stormwater. This guidebook presents a range of strategies from large-scale river basin planning, to an ecological model of development and a conservation-minded garden.

It is critical to use design techniques that protect the precious water resources of the coastal plain and estuaries.



Landscape design strategies can protect water quality in the estuarine zone.

INTRODUCTION

The land is always changing — either by natural or human disturbances. Nature's changes can be gradual, almost imperceptible. Or they can be totally and immediately disrupting, such as with hurricanes, tornadoes, fire, flood or drought. Nature's infrequent catastrophic events often are considered "cleansing" for the environment. However, with increased estuarine development, these natural events often conflict with the built environment.

When people began to develop the coastal region, wetlands were considered more of a constraint to progress than a resource. Wetlands did not facilitate needed farms, stores, houses, timber or roads. Land was cleared, graded, filled and ditched to ease the construction process. Now, bigger machinery and new technology facilitate more changes to the land, such as draining wetlands and diverting rivers. The human footprint has become heavy on nature's systems.

Human-caused alterations are increasing, and oftentimes, these changes do not support sustainable ecosystems. Such actions have a price, and should be coupled with an understanding of long-term repercussions to the environment.

As part of *The Soundfront Series*, this guide will focus on landscape design strategies to improve estuarine water quality by mitigating potentially negative effects of development. These strategies are presented in categories relative to the scale of development. Proposals for multiuse developments, such as a shopping center, planned unit development, or office center, require "site plans." On a smaller scale are the individual parcels or lots that are designed for a single use, such as a house, office or store. Details on water quality issues will be discussed within each section. But first, it's necessary to put landscape design strategies into the proper context by considering general water quality concerns in the estuarine zone.

RIVER BASIN PLANNING

River basins, comprised of many sub-basins or watersheds connect the network of land types through the flow of water. Runoff and groundwater connect all parts of the coastal ecosystem. Thus, we first must consider the river basin issues before developing design strategies. In *Blueprint to Protect Coastal Water Quality,* the Maryland-based Center for Watershed Protection recommends a series of steps to protect coastal water quality. The first step is to begin planning on a watershed basis — a formidable task, as watersheds rarely coincide with county or town boundaries. Implementing a watershed-based program requires coordination with neighboring towns, counties, and possibly another state. The North Carolina coastal plain contains the Chowan, Roanoke, Pasquotank, Tar-Pamlico, Neuse, White Oak, Cape Fear and Lumber river basins. The N.C. Division of Water Quality, within the Department of Environment and Natural Resources, has developed management plans for each basin. Online, information is available at *www.esb.enr.state.nc.us.*

The regional council of government organization or the state's basinwide planning program can provide planning guidance. These agencies can help identify water quality issues, recommend strategies, and facilitate partnerships among communities and other interested parties. For more information on watershed-based planning, see *Protecting the Estuarine Region Through Policy and Management* by Walter Clark, another guide in *The Soundfront Series.*

STORMWATER CONCERNS

At one time, the majority of the coastal plain was covered with a seemingly endless network of swamps, pocosins, wetlands, meadows and woodlands. Each landscape type has a particular function within the overall coastal ecosystem. The significance of wetlands to hydrology and water quality cannot be overstated. Wetlands cleanse water, store floodwaters and provide habitat for a diverse population of flora and fauna. Other natural landforms contribute to clean, healthy waters. For example, sandy soils filter rainwater and recharge fresh water aquifers. Pocosins, which often appear dry, are the source of water for many coastal streams. Working with the land in a sustainable manner requires knowing these varied landscape functions and working to sustain them.

Algal blooms, fish kills, widespread shellfish closures and diminishing populations of benthic invertebrate populations — the basic food group in the aquatic food chain — are cited as signs that the coastal ecosystem's health is in jeopardy.

These problems may be linked to various land-use activities that have altered native land cover, landforms and their functions, as well as to the pollutants they deliver (**Figure 1**). Past land-use activities, such as farming and forestry, fundamentally altered watershed hydrology by reducing infiltration, retention and storage, while at the same time increasing stormwater runoff volume, velocity and pollutant loading. However, there are design strategies and techniques that can maintain, restore or mitigate the functions of landscape units in a watershed. Thus, each design phase of a project can be a step toward a positive cumulative impact within the estuary.

Increased stormwater runoff is one manifestation of an altered landscape. Stormwater is a significant source of excess nutrients, sediment and bacterial pollution to estuarine waters. For example, sediment transports toxins, fills stream channels and reduces flow capacity and habitat. Excessive sediment also smothers bottom-dwelling or benthic macroinvertebrate populations that are the primary source of food for other organisms.

Likewise, increased nutrient loading of nitrogen and phosphorus alters the food chain by fostering excessive algal growth. Such excessive growth is not a useful food source to many indigenous organisms. Rather, algal growth reduces habitat, crowding out other organisms by taking up precious space in the water column, as Barbara Doll and Lundie Spence of North Carolina Sea Grant explain in

Coastal Water Quality Handbook. As algae are decomposed by microorganisms, oxygen is consumed, thus limiting the oxygen available for fish. Malfunctioning septic systems and runoff can contaminate the water column with pathogens, rendering it and food supplies unfit for human contact and consumption.

While it may not be possible to eliminate all impacts related to development, studies indicate that improved land management and development practices can substantially reduce surface runoff volume and pollutant loads. These techniques are based in science, but also reflect tradition and common sense. Together, these practices can help maintain healthy estuarine ecosystems.

CUMULATIVE IMPACTS OF POLLUTION

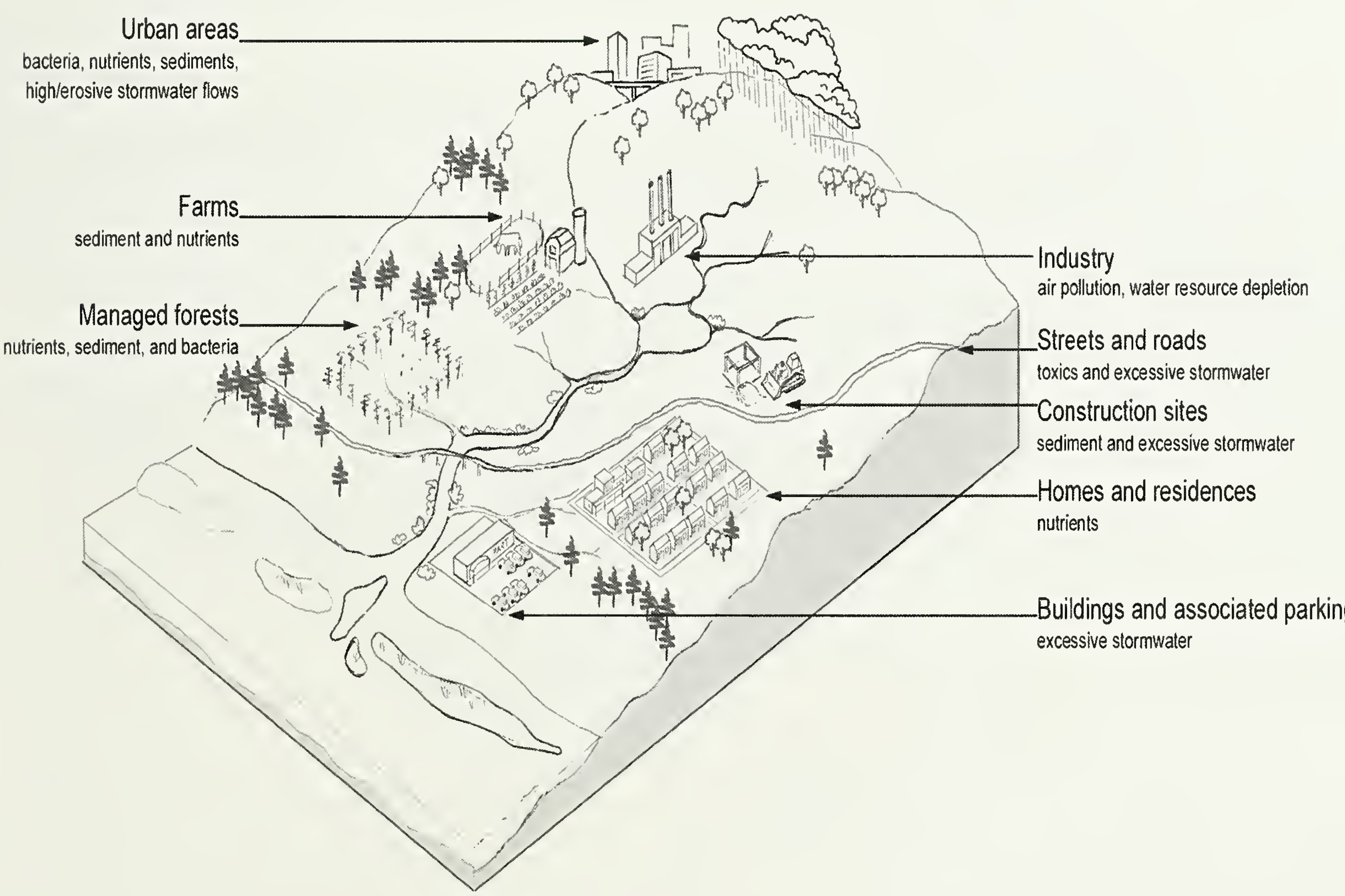


Figure 1: Cumulative Impacts of Pollution. *On a watershed basis, pollutants are connected by water draining from the top to the bottom of the system, thereby increasing pollutants, including toxics, delivered to the estuaries.*

Chapter 2: Designing Site Plans

Whether planning for a region, designing for a site, or building a single structure, communities and individuals need to take steps to protect the estuaries. This chapter introduces techniques that will help to reduce the impacts related to the design and construction of multiuse development projects, such as commercial centers, residential areas or industrial sites.

INTRODUCTION

Specific portions of a watershed are critical to the maintenance of water quality. These include riparian buffers, estuarine shorelines, coastal wetlands, groundwater recharge areas, floodplains, steep banks, headwater streams and woodlands. An overall watershed assessment can aid in identifying, quantifying and preserving these areas. A hydrologist or ecologist can conduct the assessment for a community or group interested in land conservation and water quality. For more information about the coastal landscape and watersheds, see *Shoreline Erosion in North Carolina Estuaries* by Stanley R. Riggs. For more information about tools, strategies and resources to facilitate water quality-based conservation within the context of the land-use planning process, see *Protecting the Estuarine Region Through Policy and Management* by Walter Clark. Both are guides in *The Soundfront Series.*

Watershed assessments help delineate areas needed for land conservation. These assessments also identify areas suitable for development, or what some call "development envelopes." The portion of the watershed landscape containing stable slopes, soils and shorelines is the most suitable area for development. Dense developments should be concentrated on these sites. In reality, however, development cannot always be located in the most "environmentally suitable" locations. Development occurs in response to many factors, such as local market trends and community needs. As a result, compromises are made throughout the process of planning and building.

Homeowners and developers may choose from a variety of permeable paving materials to mitigate runoff from "hardened" surfaces.

DEVELOPMENT FORMS

Depending upon many variables, the development may take any of several physical forms, including low-density, neo-urbanism, infill or clustering. Each has the potential to be designed in a sustainable manner.

• ***Low-density development*** has been a typical development pattern for many years (**Figure 7**). It is also often called sprawl, but impacts related to this approach, like any other, depend on how it is designed, fit into the land, and planned as part of the larger community and watershed program. To reduce impacts on watershed processes, low-density development activities should exist without much support from municipal infrastructure.

• ***Neo-urbanism*** seeks to reconstruct small-town relationships using mixed residential types interspersed with commercial and community development (**Figure 5**). This style is typically very high density, thus its watershed location should be one that can tolerate high levels of impervious surfaces and can offer ample opportunities and space to mitigate high impacts related to the impervious surfaces.

• ***Infill*** is a strategy that promotes new activities within existing areas of development in order to take advantage of infrastructure and resources, such as water, sewer, phone or other utilities (**Figure 6**). A primary concern with this style is whether the current infrastructure can tolerate an increase in density. Also, because this approach results in a more compact, urban form, it should be paired with an effort to integrate open space into the plan and design. Some sites may require a "retrofit" of existing stormwater treatments to include the sustainable techniques.

• ***Clustering*** uses variable lots sizes, thus allowing the designer to fit land uses to the landscape and set aside areas for conservation (**Figure 7**). The flexibility of clustering allows this development style to be located almost anywhere. This approach can be very effective for maintaining ecosystem functions and watershed hydrology when the open space corresponds with hydrologically sensitive areas and important habitats.

However, whether a site is ideal or marginal, there are techniques which can reduce negative impacts to estuarine water quality. Many of the techniques referred to as "sustainable" or "low-impact" designs are discussed in *Low-Impact Development Strategies: An Integrated Design Approach* from Prince George's County, Md. Supplemental information can be found in documents produced by The Center for Watershed Protection, such as *Blueprint to Protect Coastal Water Quality*. This chapter provides an overview of these techniques. For a more detailed discussion, consider these and additional sources listed at the end of this guide.

SUSTAINABLE DESIGN STRATEGIES

Regardless of development form, there are many opportunities to enhance environmental sustainability with each. Sustainable design has different objectives from conventional design (**Figure 2**). It seeks to protect water quality through maintenance of site hydrology; reduction in stormwater generated through minimization of impervious surface area (**Figure 3**); and provision of as many opportunities to treat and manage stormwater on site using a variety of integrated management techniques (**Figure 4**). However, when considered early in the process, these objectives can be incorporated into any development project.

Various important elements contribute to reducing the negative impacts of the development. Following is a discussion of several elements and how sustainable design can help.

Grading and Construction

Cleared, graded and compacted land reduces hydrologic functionality. One alternative is to use variable floor elevations, pier construction, and multifloor buildings. For example, when a building is all one level, more of the site must be graded flat. Designing the building to fit the land protects and conserves desired portions of the landscape. It also minimizes the extent of areas that must be surveyed and cleared at any one time, allowing the construction

COMPARISON OF CONVENTIONAL AND LOW-IMPACT DEVELOPMENT STORMWATER MANAGEMENT GOALS

Hydrologic Parameter	Conventional	Low-Impact Design
	On Site	
Impervious Cover	Encouraged to achieve effective drainage	Minimized to reduce impacts
Vegetation/Natural Cover	Reduced to improve efficient site drainage	Maximized to maintain predevelopment hydrology
Time of Concentration	Shortened, reduced as a by-product of drainage efficiency	Maximized and increased to approximate predevelopment conditions
Runoff Volume	Large increases in runoff volume not controlled	Controlled to predevelopment conditions
Peak Discharge	Controlled to predevelopment design storm (2 year)	Controlled to predevelopment conditions for all storms
Runoff frequency	Greatly increased, especially for Small frequent storms	Controlled to predevelopment conditions for all storms
Runoff duration	Increased for all storms, because volume is not controlled	Controlled to predevelopment conditions
Rainfall Abstraction (Interception, Infiltration, Depression Storage)	Large reduction in all elements	Maintained to predevelopment conditions
Groundwater Recharge	Reduction in recharge	Maintained to predevelopment conditions
	Off Site	
Water Quality	Reduction in pollutant loadings but limited control for storm events that are less than design discharge	Improved pollutant loading reductions, Full control for storm events that are less than design discharge
Receiving Streams	Severe impacts documented- Channel erosion and degradation Sediment deposition Reduced base flow Habitat suitability decreased, or eliminated	Stream ecology maintained to predevelopment
Downstream Flooding	Peak discharge control reduces flooding immediately below control structure, but can increase flooding downstream through cumulative impacts and superpositioning of hydrographs	Controlled to predevelopment conditions

Figure 2: Comparison of Stormwater Management Goals. *Conventional stormwater management goals differ greatly from low-impact design strategies. Treating and managing water on site is an important component of low-impact design.*

process to be phased more easily.

Phased construction reduces exposed soils, and hence, potential on-site erosion and off-site sediment transport. In addition, reduced clearing and grading requires smaller grading equipment, which lessens the extent of areas affected by compaction and other disturbances.

To further protect land functions, plant protection zones should encompass entire landforms and plant communities, not just individual trees. Protection barriers should be placed beyond tree drip lines to better ensure survival. These practices also help to maintain site microtopography and functionality, allowing these areas to capture and infiltrate stormwater.

Roads

The road network usually is the single most significant element within a project. Roads contribute considerable imperviousness — and stormwater runoff. Massive areas of clearing and grading are required for road construction. However, the placement and design of roads can help to reduce negative impacts.

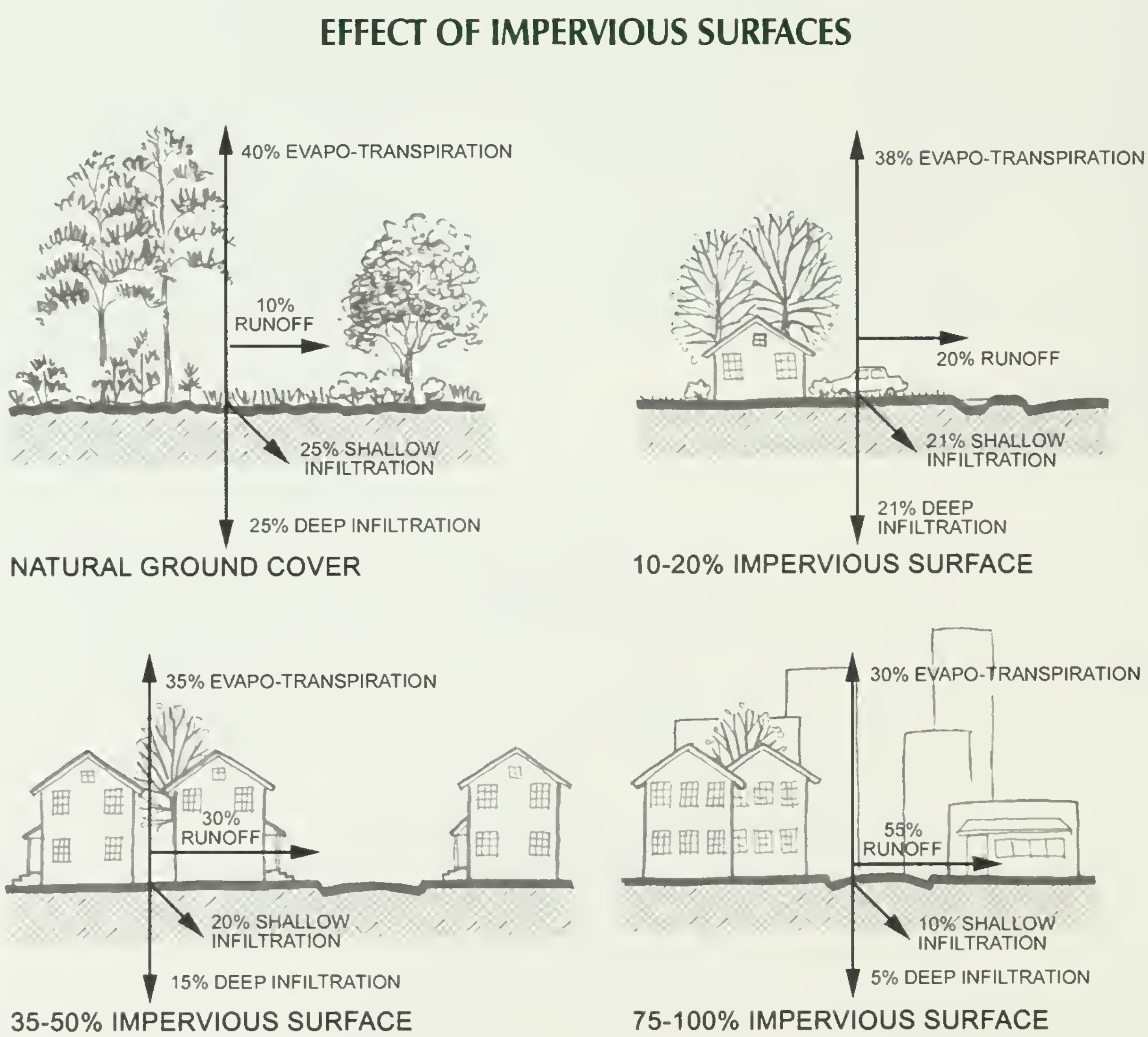


Figure 3: Effects of Impervious Surfaces. Imperviousness is one of the single largest design elements in any project affecting total volume of stormwater runoff. Reductions in imperviousness offer the greatest opportunity to reduce stormwater runoff.

Roads should not be sited on steep slopes, near banks, or in low, wet areas. Traditionally, roads were located along the ridgelines that provided dry, high ground. These roads would cross valleys only where absolutely necessary, thus requiring less cut/fill and providing easier access to stable soils. This approach provides opportunities to maintain landscape functions. This traditional practice is recommended in today's "toolbox" of sustainable design techniques.

Roads should follow the natural contours of the land. In doing so, gradient is reduced, minimizing runoff velocity. Utilizing a flexible and varied system of loops, cul-de-sacs and road widths, the designer can fit roads into the landscape to reduce road length, site impact and overall imperviousness (**Figure 3**).

How the actual road is designed also can facilitate stormwater management. Gently pitching the road grade from one side then the other slows water and allows dispersal to collection and retention areas for treatment. The

INTEGRATED STORMWATER MANAGEMENT

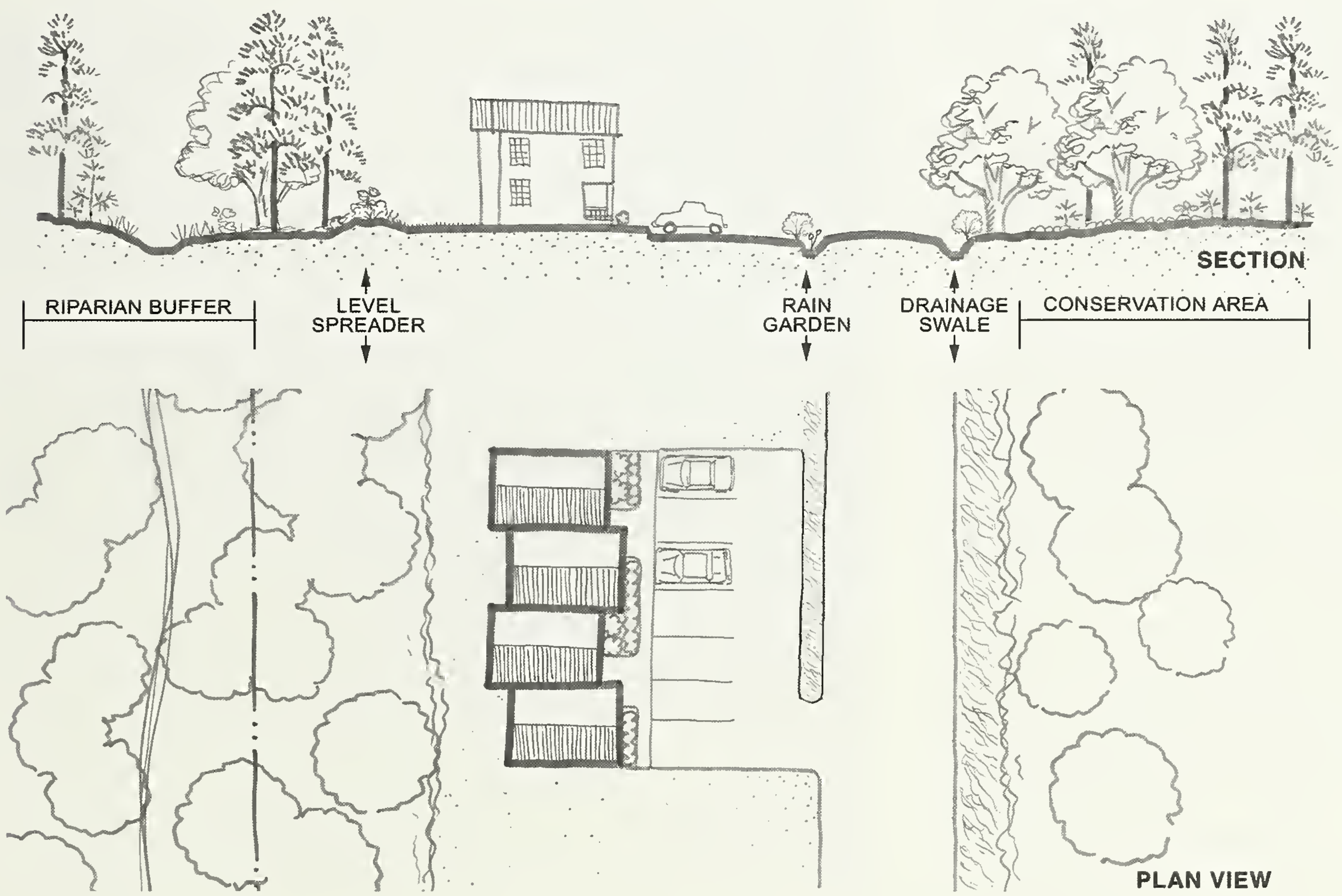


Figure 4: Integrated Stormwater Management. *Integration of many management techniques within the site allows many opportunities for stormwater treatment and management.*

designer can integrate stormwater controls into the road system more easily using this technique. Another way to control flow and direction is to invert the crown of the road. This enables the designer to use the road to transport water to infiltration areas — reducing the need for drain pipe, curb and gutter. Pipe, curb and gutters should be used sparingly and only to strategically direct water.

Often curb and gutter are used to stabilize road edges and provide a neat appearance. Another technique to accomplish these objectives and to provide sheet flow along the road length, is to use flat concrete aprons. Laid along the length of the road, aprons ensure a stable, firm road edge, but allow water to sheet flow from the road to grassy swales or other treatments.

To further reduce pavement, the width of neighborhood roads can be narrowed from the current standard of more than 30 feet to 18-22 feet. Studies show that narrow roads are safe, cost less to maintain and can accommodate a variety of traffic patterns, while allowing for emergency vehicles. One-way streets, pull-off lanes and alleyways are design techniques that allow for flexibility and reduced paving volumes, while effectively managing traffic flow.

Use of permeable pavement — such as porous concrete and asphalt, brick and sand, paving block, cobbles or gravel — can further reduce the negative impacts associated with roads. Alternative permeable paving materials are suitable for flex, overflow or light traffic areas. These materials require precise site preparation and an ongoing maintenance schedule.

More information about this and other techniques can be found in *Design of Stormwater Infiltration Systems* by The Center for Watershed Protection.

Revisions to local zoning ordinances may be needed to allow use of alternative road designs. The Center for Watershed Protection's *Better Site Design: A Handbook for Changing*

NEO-URBANISM AND LOW-IMPACT DESIGN

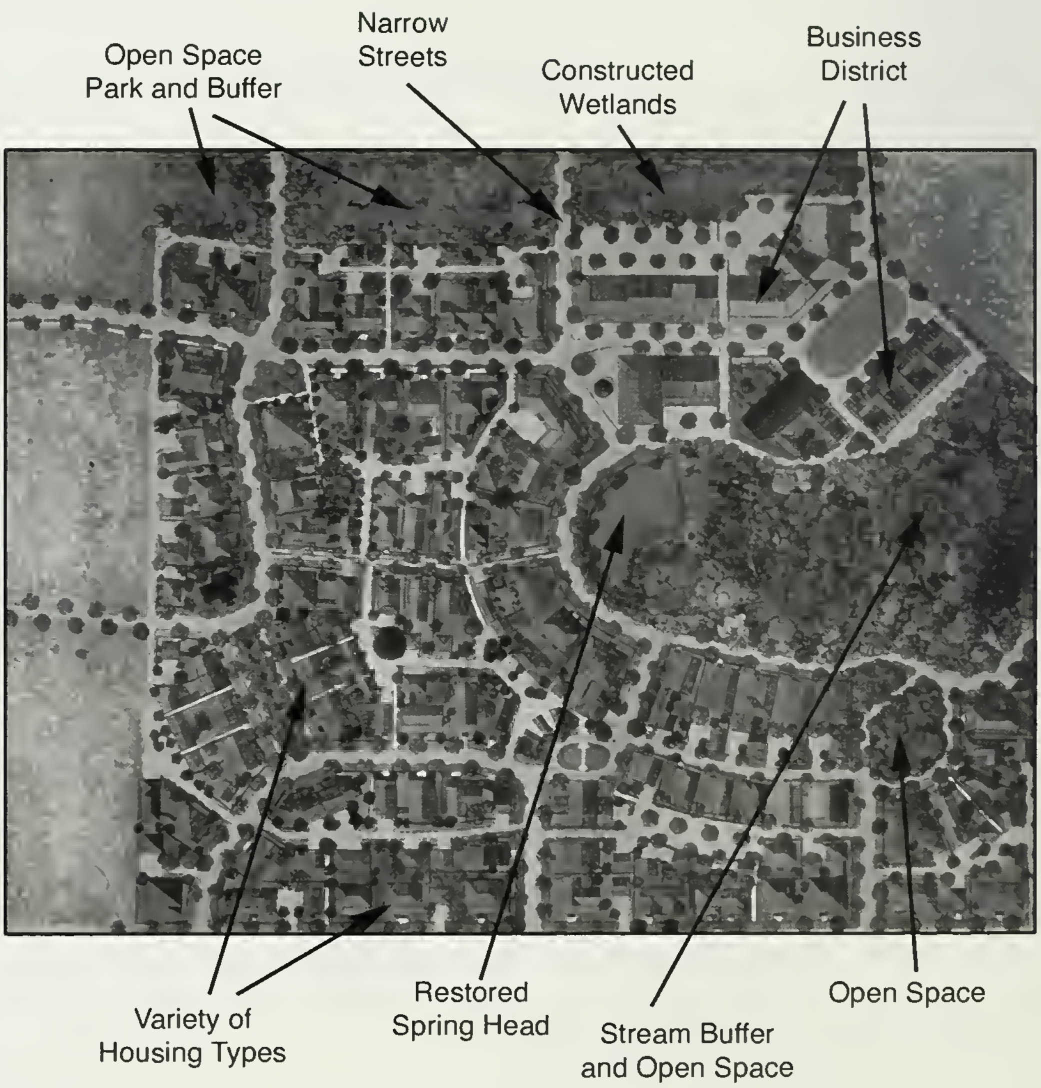


Figure 5: Example of Neo-Urbanism. *Neo-urbanism can be very high impact because of the density. Stormwater management must be well-integrated with the site design to minimize negative impacts on water quality.*

Development Rules in Your Community provides an evaluation tool to identify areas needing modification. The manual also offers tips for working within the community to encourage and implement change.

Parking Lots

Today's society is very automobile-oriented. This orientation is strongly linked with economic development. Hence, parking and driveways have been focal points in many designs. However, sufficient parking and access can be provided along with reductions in pavement. One approach is to have various activities sharing driveways and parking lots. Communities and local governments also can work together to create community parking areas, thus eliminating the need for each business to build for its maximum parking need.

Further reductions can be achieved by using angled parking and one-way access. These techniques allow for more parking slots in a smaller area. Alternative pavements, such as those listed in the roads section, can be used for both parking and drives. These materials slow water runoff by increasing the time of concentration.

INFILL DEVELOPMENT

Figure 6: Example of Infill Development. *Infill development reduces overall watershed impacts by utilizing existing infrastructure and increasing density in existing developed areas.*

Sidewalks

When sidewalks are built in parallel lines with the street, often all that is left is a tiny strip of grass between the street and the walk. This area is too small to allow adequate tree growth, or to accommodate any type of stormwater treatment device. These negative aspects are further compounded by the need to mow and trim the grass.

Sidewalks can weave in and out of the landscape and be placed with an adequate setback to support large shade tree growth. This allows for stormwater treatment of road and walkway runoff. Shade trees are important for reducing hot spots. Trees intercept rainwater and dust, reduce carbon dioxide and provide infiltration. Microstormwater treatment areas such as dry wells, miniwetlands,

rain gardens and biofilters also fit well into these spaces.

Pavement, construction and easement costs can be reduced by putting sidewalks on one side of the street, then designing for safe pedestrian crossovers. Wherever appropriate, permeable material should be used.

Sidewalks are a sensitive community subject. They have become the icon of homey, old-fashioned neighborhoods. Neither dual nor single walks will be the solution for all situations. But, when trying to reduce stormwater impacts, it pays to assess more closely whether there are low-impact alternatives that can meet community needs.

SUSTAINABLE DESIGN PROCESS

What are the best places for these elements? How will they accomplish the goals of the design and watershed sustainability? Many factors influence design program and development form such as the scope of the design. Will it be a 50 single-family house site, a "big box" retail store or a mix of uses? The scope of the project is a factor in the overarching goal — profitability. All projects must comply with the community's development ordinances and the state regulations for road, waste management, lighting and building codes. Thus, focusing on water quality may seem overwhelming when added to an already complex task. Yet with

LOW-DENSITY AND CLUSTER SITE DESIGN

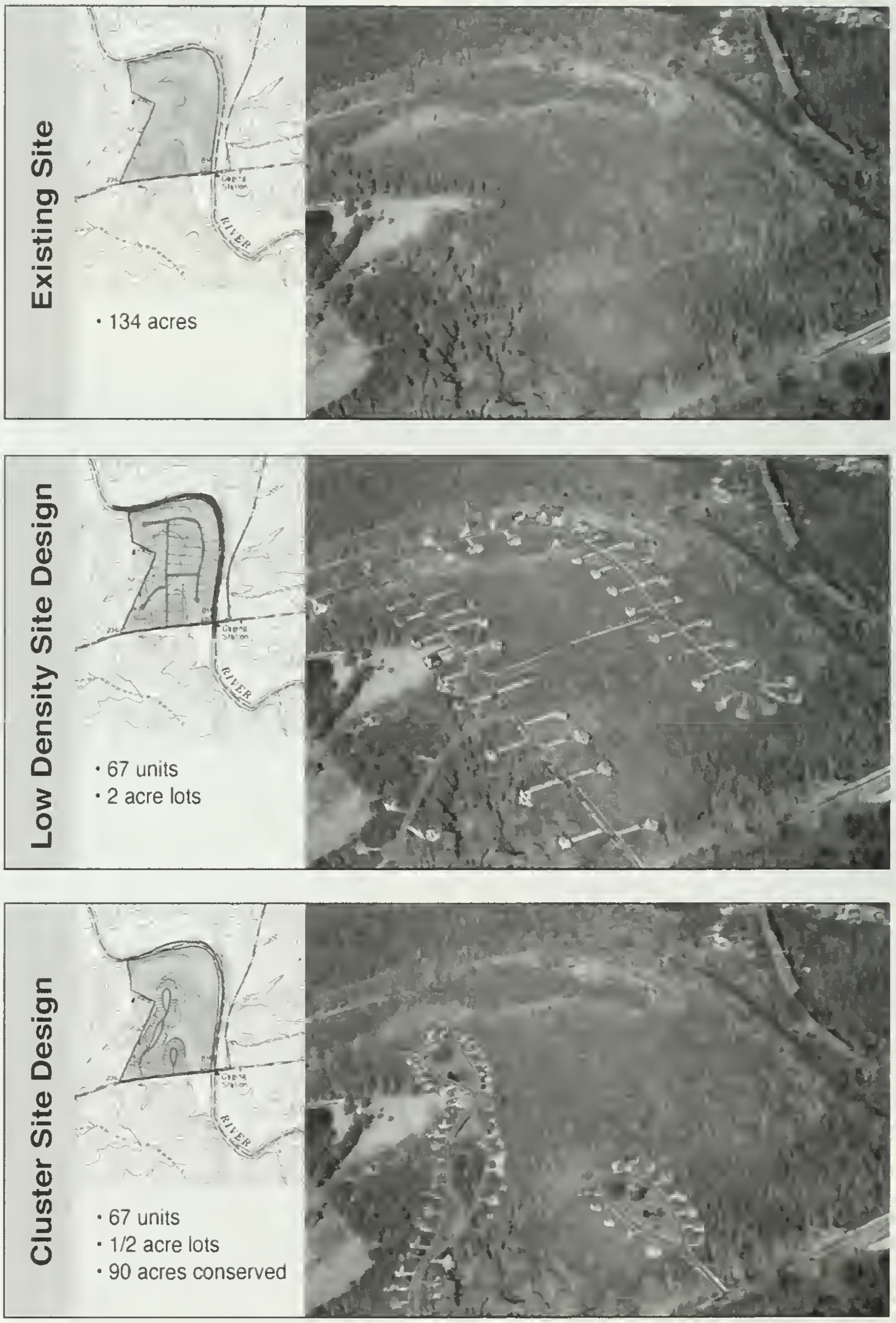


Figure 7: Example comparing Cluster and Low-Density Development. *Cluster uses variable lots sizes to reduce impacted area and preserve open space. Low-density development can spread impacts over a larger area.*

forethought, a designer often can create a "sustainable" site plan that works for the developer and the environment.

Such efforts to protect water quality require a multidisciplinary design process, using both quantitative and qualitative techniques. These techniques should strive to provide postdevelopment site hydrology comparable to, or better than, predevelopment conditions. Overall strategies will include:

- finding ways to reduce stormwater runoff
- keeping the water on site as long as possible
- reinfiltrating stormwater
- treating the runoff prior to release into nearby streams and estuaries

Step One: Review the Site's Natural Resources

While most development projects include site assessments, too often the objective is to determine project constraints in light of significant or protected plant material, wetlands or soil limitations. A site assessment can identify resources that can enhance the project's design, facilitate stormwater design and protect the overall community's water resources. This step is critical to the objective of controlling and treating stormwater runoff.

To understand watershed functions within the site, a thorough assessment should identify, quantify and map:

- contiguous plant communities
- intermittent and perennial streams
- landforms
- wetlands
- soil types
- groundwater recharge areas
- riparian zones adjacent to flowing water
- wildlife habitat

Step Two: Conduct a Hydrologic Assessment

The hydrological assessment process is used to determine the effectiveness of the proposed site design in maintaining predevelopment site hydrology. This process involves:

- quantification of existing hydrological functions
- development of low-impact design
- assessment of design impact
- design refinement
- reassessment
- adoption of best management practices

The process is repeated until the designer determines that the impacts of the development have met the goals of the design and water quality.

The process is described in detail in *Low-Impact Development Strategies: An Integrated Design Approach*, a manual from Prince George's County, Md. Other resources include *Better Site Design: A Handbook for Changing Development Rules in Your Community* and *Design of Stormwater Infiltration Systems*, both by The Center for Watershed Protection.

Step Three: Integrate Best Management Practices

Once the impact of the design is reduced to a minumum, best management practices (BMPs) can be integrated into the program to meet the goals of stormwater management and treatment goals as well as the design program (**Figure 8**). Best results can be achieved when best management practices noted in Figure 8 are integral components of a sustainable site design process.

With an understanding of site conditions and functions, as well as storm event hydrology, the design team can artfully and scientifically integrate various techniques with the water quality design program to minimize stormwater generation, control volume and treat pollutants.

In the development of a stormwater management plan, it is important to note that in North Carolina's coastal plain, 90 percent of rainfall occurs in 1-inch or 2-inch storm events. Most of the pollutant loading occurs during these events. Hence, stormwater management techniques used to treat pollutants need to be designed for the volume of water generated during typical storms. Additional methods are needed to control the peak flows for extreme events — the 10-, 25-, or 50-year storms — that cause most of the erosion and stream bank damage.

For example, landscape design elements, such as riparian buffers, wetlands, floodplains and bioretention areas can provide habitat, cleanse water

and store floodwaters, while at the same time serve as community parks, trails and open space. Grassy swales can do triple-duty as sediment traps, road easements and walkways — as long as they don't deliver stormwater directly into surface waters. Therefore, stormwater management can be a water quality benefit and project asset, not just a costly requirement.

To determine which treatment meets project goals, consider the wealth of published information on the design and use of BMPs. Much of it can be found online at the Web sites for The Center for Watershed Protection and North Carolina State University's Department of Biological and Agricultural Engineering. Optimal results can be achieved when stormwater management and water quality are an essential part of the design process.

CONCLUSIONS

Designing to protect the estuaries requires an understanding of the landscape upon which structures are built. This not only benefits the individual development, but also maintains functions important to water quality. Thus, some areas — such as riparian buffers, estuarine shorelines, coastal wetlands, groundwater recharge areas, floodplains, steep slopes, headwater streams and woodland communities — must be conserved, even within the "development envelope."

To reduce overall watershed impacts, development can be concentrated within areas already disturbed and within development envelopes. In addition, existing areas can be retrofitted with improved stormwater treatment and control options. However, stormwater management techniques to protect water quality are easier — and cheaper — if they are considered from the outset. Each new project within the coastal area should be designed to control and treat stormwater on site. While some developers may consider these options "compromises," such techniques are critical to "sustainable" coastal development.

On the flip side, how can the development community be motivated to utilize these practices? It is important to realize that the development business is complicated, time consuming and risky. Navigating through the permitting maze is not an easy task. Working through all the interdependencies is difficult and takes time. Making money is a development necessity just the same as maintaining good water quality is an environmental necessity.

Paul Hawken, in his book *The Ecology of Commerce*, references commerce as potentially the most powerful engine of environmental quality we may have. Developers know that a good environment sells — now more than ever.

CHARACTERISTICS OF BEST MANAGEMENT PRACTICES

	BIORETENTION	DRY WELL	FILTER OR BUFFER STRIP	SWALES	RAIN BARREL	CISTERN	INFILTRATION TRENCH
Space Required	Minimum surface area range: 50 to 200 f ^{2} Minimum width: 5 to 10 ft Minimum length: 10 to 20 ft Minimum depth: 2 to 4 ft	Minimum surface area range: 8 to 20 f ^{2} Minimum width: 2 to 4 ft Minimum length: 4 to 8 ft Minimum depth: 4 to 8 ft	Minimum length of 15 to 20 ft	Bottom width: 2 ft minimum, 6 ft maximum	Not a factor	Not a factor	Minimum surface area range: 8 to 20 f ^{2} Minimum width: 2 to 4 ft Minimum length: 4 to 8 ft
Soils	Permeable soils with infiltration rates > 0.27 inches/hour are recommended. Soil limitations can be overcome with use of underdrains	Permeable soils with infiltration rates > 0.27 inches/hour are recommended	Permeable soils perform better, but soils not limitation	Permeable soils provide better hydrologic performance, but soils not a limitation. Selection of typ of swale, grassed, infiltration or wet is influenced by soils	Not a factor	Not a factor	Permeable soils wit infiltration rates 0.52 inches/hour ar recommended
Slopes	Usually not a limitation, but design consideration	Usually not a limitation, but design consideration. Must locate downgradient of building and foundations	Usually not a limitation, but design consideration	Swale side slopes: 3:1 or flatter Longitudinal slope: 1.0% minimum; maximum based on permissible velocities	Usually not a limitation, but a design consideration for location of barrel outfall	Not a factor	Usually not a limitation, but a design consideration. Must locate down-gradient of buildings and foundations
Water Table/ Bedrock	2- to 4-ft clearance above water table/ bedrock recommended	2- to 4-ft clearance above water table/ bedrock recommended	Generally not constraint	Generally not constraint	Generally not a constraint		2- to 4-ft clearance
Proximity to build foundations	Minimum distance of 10 ft downgradient from buildings and foundations recommended	Minimum distance of 10 ft downgradient from buildings and foundations recommended	Minimum distance of 10 ft downgradient from buildings and foundations recommended	Minimum distance of 10 ft downgradient from buildings and foundations recommended	Not a factor		Minimum distance of 10 ft down-gradient from buildings and foundations recommended
Max. Depth	2- to 4-ft depth depending on soil type	6- to 10-ft depth depending on soil type	Not applicabl	Not applicabl	Not applicabl		6- to 10-ft depth depending on soil type
Maintenance	Low requirement, property owner can include in normal site landscape maintenance	Low requirement	Low requirement, routine landscape maintenance	Low requirement, routine landscape maintenance	Low requirement		Moderate to high

Figure 8: Characteristics of Best Management Practices. *Best management practices need to be tailored to the location, stormwater management needs and design program.*


PARK
NOAH'S GARDEN
SONGLINE STREET
CHATWIN STREET
N
W
E
S
GALT LANE
SYLVAN GREEN
VAN STREET
DOGWOOD PARK
MARKET PLAZA
WETLANDS LANE
ANDER LANE N
SONGLINE STREET
POND
WETLANDS FOREST
NATURE TRAILS
MEANDER LANE S
NOLEN STREET
VERDANT PARK
STREET
NOLEN GREEN
PICCOLO LANE
SAUNTER LANE
NOLEN STREET
ERDANT STREET
AMITY LANE

Chapter 3: Village of Woodsong: A Site Plan Case Study

Whether planning for a region, designing for a site or building a single structure, communities and individuals need to take steps to protect the estuaries. This case study reviews techniques used in the design and building of Woodsong, a low-impact, neo-urban, sustainable site plan for multiuse development on the Shallotte River.

INTRODUCTION

Specific landforms of a watershed are critical to the maintenance of water quality. These include riparian buffers, estuarine shorelines, coastal wetlands, groundwater recharge areas, floodplains, steep banks, headwater streams and woodlands. An overall watershed assessment approach identifies these systems for on-site conservation and the site "development envelope." These portions of the site will contain stable slopes, soils and shorelines and are where the most dense development should be concentrated.

This case study will provide an overview of these techniques implemented at Woodsong. Further discussion of the techniques referred to as "sustainable" or "low-impact" designs can be found in the *Low-Impact Design Strategies: An Integrated Approach* from Prince George's County, Md., North Carolina Sea Grant's publication, *Coastal Water Quality Handbook*, and various documents produced by the Maryland-based Center for Watershed Protection. Additional sources are listed at the end of this guide.

CONTEXT

The Village of Woodsong is located in the Town of Shallotte in Brunswick County, North Carolina's southernmost coastal county. The site is within the Shallotte River Watershed, a tidal creek system that begins in the Green Swamp, drains into the Shallotte Sound, through the Shallotte Inlet and into the ocean.

Many streams in this mostly rural area are already impaired due to bacterial contamination. While reasons for this impairment are complex, changes to the land cover that have altered watershed hydrology are the main culprit. Development activities in the region are on the rise, and increasing urbanization likely will add to the future water quality problems.

Developer Buddy Milliken incorporated low-impact design strategies to develop Woodsong, a neo-urban, mixed-use community near Shallotte.

Figure 9, top: *Overall Site Design/Program for Village of Woodsong.*
Figure 10, right: *Trail through the riparian buffer.*

Woodsong developer Buddy Milliken hails from this region and remembers his grandfather earning a living harvesting shellfish. He is acutely aware that his grandfather's way of life has almost disappeared. Part of his motivation for developing a "sustainable" site plan for Woodsong is to preserve the environmental integrity of Woodsong and the surrounding community.

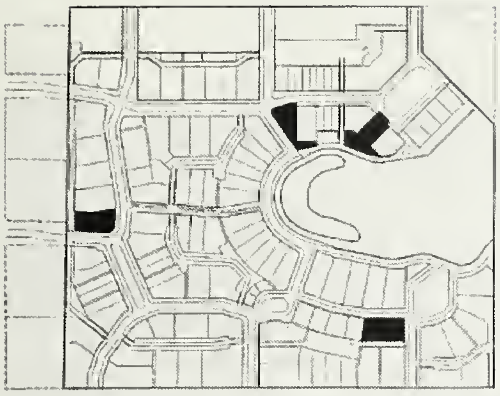


Figure 11, left: *Civic Space is incorporated into the site design.* ***Figure 12, middle*** *and* ***Figure 13, right:*** *Private space is integrated with common areas through the use of transition zones of open space.* ***Figure 14, below:*** *Pitcher plants are part of the preserved on-site wetland.*

RUNOFF VARIES WITH LAND COVER AND RAINFALL QUANTITY

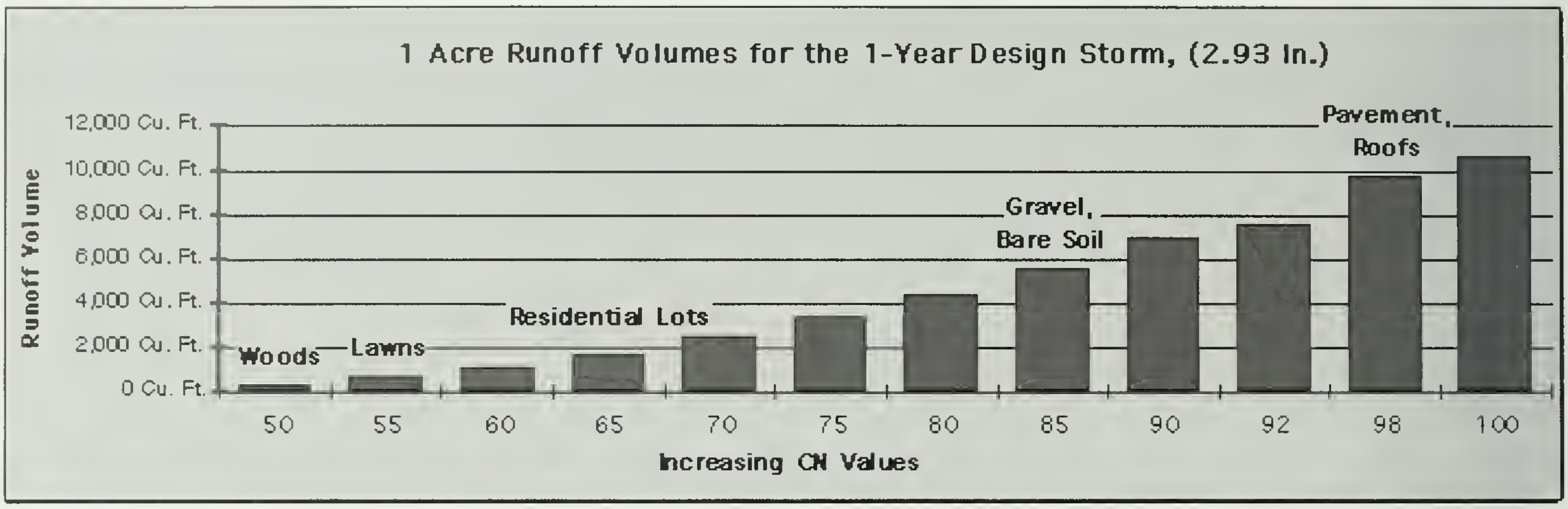


Figure 15: Runoff increases with the "hardening" of the surface. (Figure courtesy of Howard A. Partner, R.L.A.)

The site of the Woodsong development is a ditched coastal pocosin, previously harvested for timber and pine pitch. It sits within existing infrastructure for the Town of Shallotte with connection to existing paved streets, sewer, trash, police, and fire service as well as links to local parks, trails and greenways.

DESIGN PROGRAM

The Woodsong site design was developed to:

- emulate older neighborhoods, where residents can walk to a school, library, shopping center, and perform other daily activities within the neighborhood or the larger community;
- maintain a sense of place through a commitment to southern vernacular architecture. The variety of housing and workplace choices reflect coastal traditions and respects the natural landscape; and
- respect and utilize the natural resources — natural areas as parks, wetlands as open space, riparian buffers as pedestrian or bike paths (**Figures 9** and **10**).

ORDINANCE COMPLIANCE

The neo-urban aspect of Woodsong was new to the town, and thus required review and policy changes within the local uniform development ordinances. The narrow street widths and mixed land use are particularly unique to the area (**Figures 11, 12, 13**). However, even with its dense urban form, the site plan responds to the landscape of the site — thus preserving space that would maintain site hydrology and habitat.

NATURAL RESOURCES ASSESSMENT

Biologists were hired early in the Woodsong design process to assess plant communities and site functionality. An extensive audit of the vegetation and drainage patterns determined the extent and location. This enabled the designer to conserve much of the natural systems on the site. The designer capitalized on the site's natural functions, and used stormwater treatment systems that imitated the natural features and processes. The design includes constructed wetlands containing ephemeral pools and three types of insectivorous plants (**Figure 14**).

RUNOFF COMPARISONS: UNDISTURBED WOODS VS. IMPERVIOUS SURFACES

		Daily Precipitation in Inches (up to)						1 Yr Storm	2 Yr Storm
		0.25 in.	0.50 in.	1.00 in.	1.50 in.	2.00 in.	2.50 in.	2.93 in.	3.51 in.
Annual % of Rainfall Events		12%	16%	28%	19%	11%	greater than 2 inch totals 14%		
CN description	CN value	Runoff Volume							
	50	0 Cu. Ft.	0 Cu. Ft.	0 Cu. Ft.	0 Cu. Ft.	0 Cu. Ft.	86 Cu. Ft.	287 Cu. Ft.	719 Cu. Ft.
B-undisturbed woods	55	0 Cu. Ft.	0 Cu. Ft.	0 Cu. Ft.	8 Cu. Ft.	56 Cu. Ft.	299 Cu. Ft.	641 Cu. Ft.	1,267 Cu. Ft.
B-lawns in good cond	60	0 Cu. Ft.	0 Cu. Ft.	0 Cu. Ft.	15 Cu. Ft.	220 Cu. Ft.	631 Cu. Ft.	1,120 Cu. Ft.	1,945 Cu. Ft.
B-2 ac residential	65	0 Cu. Ft.	0 Cu. Ft.	4 Cu. Ft.	112 Cu. Ft.	490 Cu. Ft.	1,090 Cu. Ft.	1,722 Cu. Ft.	2,749 Cu. Ft.
B-1/2 ac residential	70	0 Cu. Ft.	0 Cu. Ft.	17 Cu. Ft.	304 Cu. Ft.	873 Cu. Ft.	1,653 Cu. Ft.	2,453 Cu. Ft.	3,682 Cu. Ft.
B-1/4 ac residential	75	0 Cu. Ft.	32 Cu. Ft.	110 Cu. Ft.	605 Cu. Ft.	1,383 Cu. Ft.	2,361 Cu. Ft.	3,323 Cu. Ft.	4,751 Cu. Ft.
B-lawns 50% cover	80	0 Cu. Ft.	68 Cu. Ft.	303 Cu. Ft.	1,037 Cu. Ft.	2,042 Cu. Ft.	3,227 Cu. Ft.	4,348 Cu. Ft.	5,969 Cu. Ft.
B-bare soil	85	37 Cu. Ft.	183 Cu. Ft.	630 Cu. Ft.	1,640 Cu. Ft.	2,886 Cu. Ft.	4,278 Cu. Ft.	5,553 Cu. Ft.	7,351 Cu. Ft.
B-gravel, Industrial	90	74 Cu. Ft.	338 Cu. Ft.	1,163 Cu. Ft.	2,481 Cu. Ft.	3,971 Cu. Ft.	5,557 Cu. Ft.	6,969 Cu. Ft.	8,920 Cu. Ft.
Gravel Parking	92	92 Cu. Ft.	498 Cu. Ft.	1,461 Cu. Ft.	2,907 Cu. Ft.	4,490 Cu. Ft.	6,146 Cu. Ft.	7,605 Cu. Ft.	9,606 Cu. Ft.
Pavement, Roofs	98	394 Cu Ft	1,154 Cu Ft	2,871 Cu Ft	4,647 Cu Ft	6,441 Cu Ft	8,243 Cu Ft	9,796 Cu Ft	11,893 Cu Ft
Total rainfall capture	100	908 Cu. Ft.	1,815 Cu. Ft.	3,630 Cu. Ft.	5,445 Cu. Ft.	7,260 Cu. Ft.	9,075 Cu. Ft.	10,636 Cu. Ft.	12,741 Cu. Ft.

Figure 16: *Comparison of predevelopment hydrology with postdevelopment hydrology. (Figure courtesy of Howard A. Partner, R.L.A.)*

STORMWATER DESIGN TECHNIQUES

Site hydrology is drastically changed when the land cover is altered (**Figure 15**). Runoff volume can double when the landscape is paved. To know the extent to which a site plan has altered the site hydrology, the designer can use a model to quantify total runoff, time of concentration (TOC), and peak discharge for both typical and extreme storms for all subwatersheds on the site. Various factors, such as soil type, rainfall rate and the "hardness" of the landscape figure into the model. The hardening factor is expressed by the Curve Number (CN). This coefficient describes the volume of water that will run off, as a percent of the total, depending on the land cover. For example, the CN for a parking lot is generally about 0.90, meaning that 90 percent of the rain that falls on the surface will run off. Stormwater treatments are then designed to restore the water budget by retention, treatment, infiltration — all designed to lower the volume of runoff and to clean that water that does run off (**Figure 16**). By comparing pre- and postdevelopment hydrology, the design can be "tweaked" to maintain the predevelopment water budget.

Various techniques implemented at Woodsong minimized stormwater generation, controlled volume and treated pollutants — all actions that work toward the goal of maintaining predevelopment hydrology. To minimize stormwater generation, the Woodsong project uses an 18-foot street width — narrower than typical — with grass swales along the sides to infiltrate and filter stormwater. Instead of curbs and gutters, the streets have a reverse crown that collect water within the street and direct it to the treatment areas located strategically throughout the site (**Figure 17**).

To treat the stormwater that is generated, stormwater systems also can double as greenspace. At Woodsong, two constructed wetlands/parks are an integral part of the stormwater treatment. They consist of two small ponds, a series of marshes and a planned boardwalk/gazebo resulting in a net increase of on-site wetlands and an overall park-like, natural appearance to the project.

The constructed stormwater wetland is designed to filter out pollutants, increase time of concentration, and to provide a site amenity for the residents (**Figures 18**). This facility treats the stormwater for the east side of the project. The restored/preserved wetland maintains the headwater spring

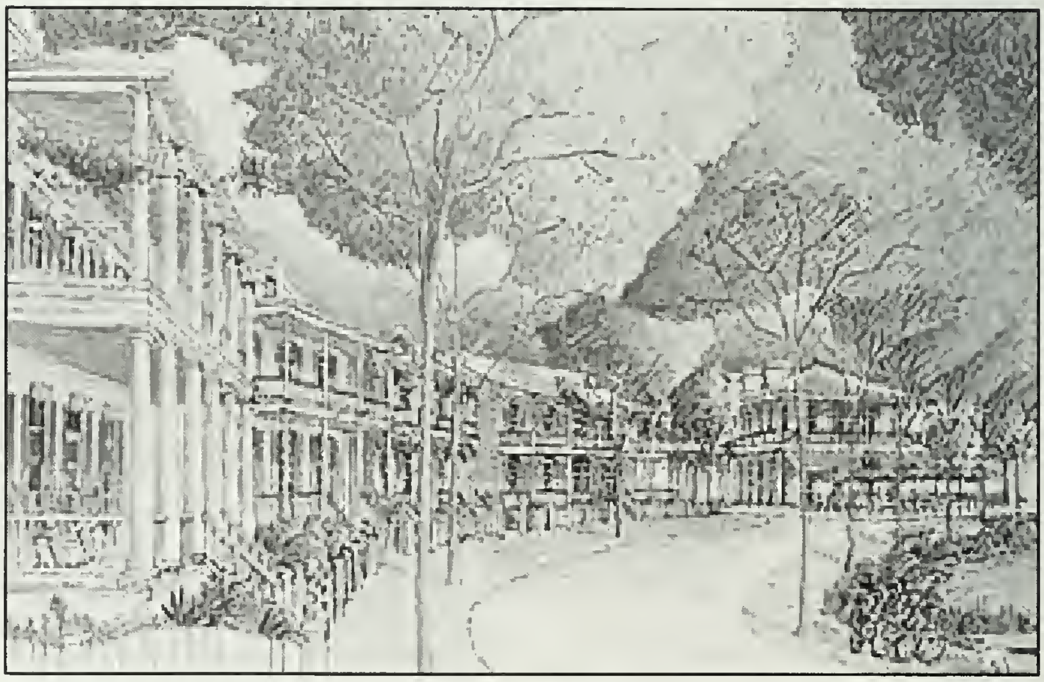
for a small stream on site. It has a pond forebay with a littoral fringe to filter out sediments and pollutants prior to interacting with the wetland area.

Woodsong also set landscape standards that encourage use of native plants, thus minimizing the need for irrigation and fertilizing. Each landowner, whether he owns one of the village shops or a home, is encouraged and provided support to utilize practices to retain and treat stormwater on each lot. Through the use of small ponds, cisterns and native plants, stormwater is reduced, treated and cleaned. The cisterns and courtyard ponds do dual duty as they harvest rainfall for irrigation and other nonpotable water uses, while minimizing stormwater runoff (**Figure 19A** and **19B**).

CONCLUSIONS

To reduce overall watershed impacts, development can be concentrated within areas already disturbed and within "development envelopes." Woodsong is an infill, low-impact and neo-urban project. It is located within the existing infrastructure for the Town of Shallotte and uses neo-urban design standards. Each new project within the coastal area should be designed to control and treat stormwater on site. In addition, these techniques can be used in existing developments to retrofit for improved stormwater treatment and control options. However, stormwater management techniques to protect water quality are easier — and cheaper — if they are considered from the outset.

While some developers may consider these options "compromises," such techniques are critical to "sustainable" coastal development. In the case of Woodsong, the developer chose these



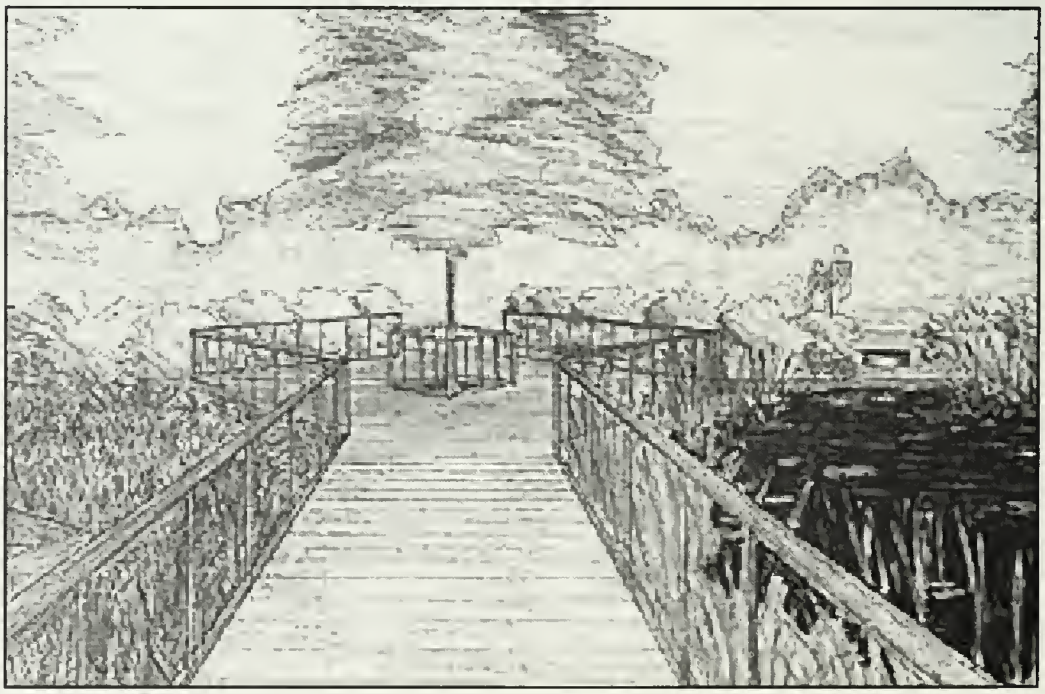


Figure 17, top: *Illustration of Songline Street.* ***Figure 18, bottom:*** *Stormwater wetland is a site amenity with gazebo and aesthetically pleasing design.*

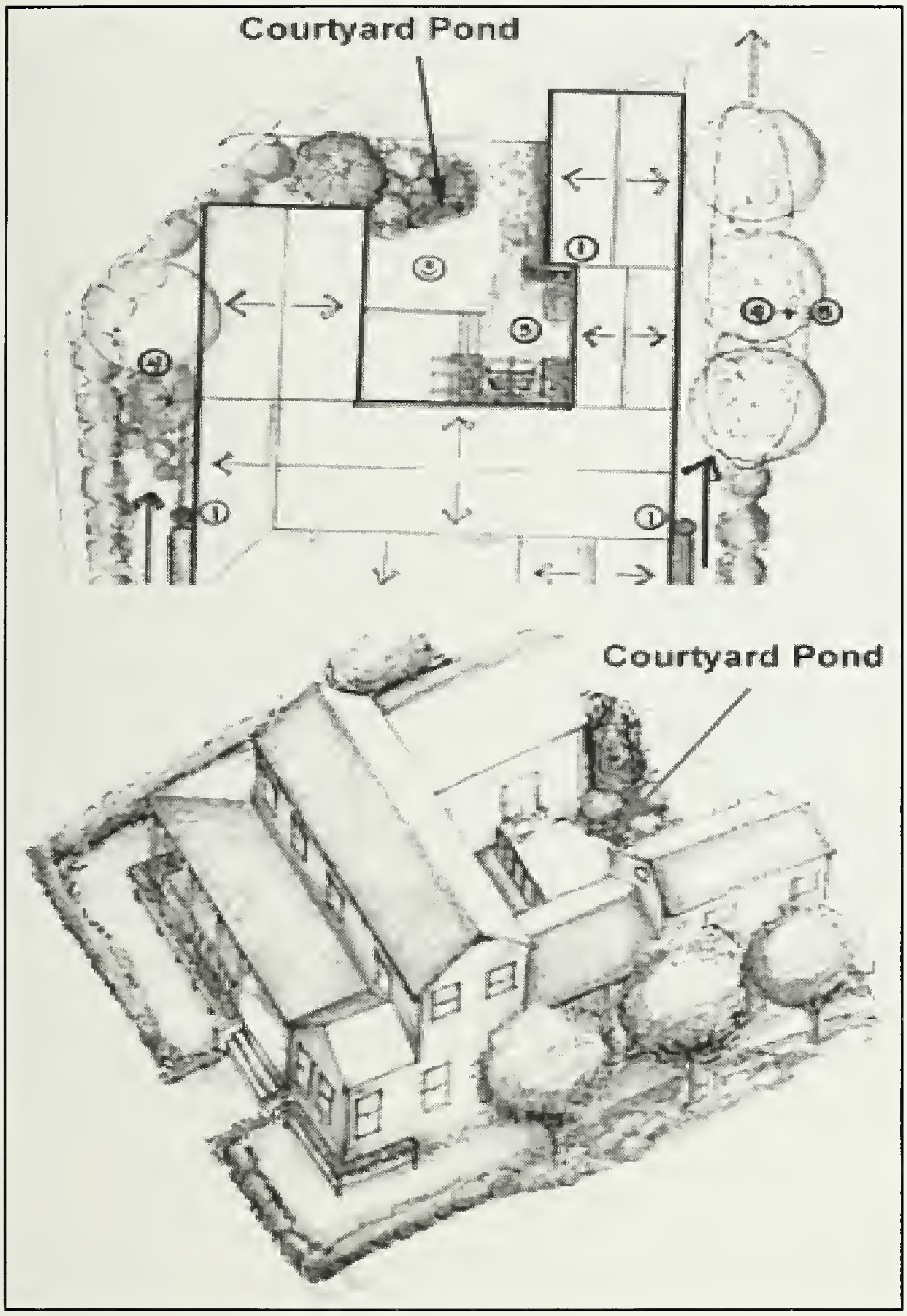


Figure 19A, top: *Mapping rooftop and landscape drainage patterns will help in the location of water-gathering treatments such as ponds, rain gardens, dry wells or rainwater collection systems.*

Figure 19B, bottom: *Collected rainwater can be reused for landscape irrigation, automobile and pet washing, toilet flushing — or any other nonpotable use. Each home roof has the potential to generate thousands of gallons of water for collection each year.*

systems and this approach because they are practical, easy to maintain, and enhance the site. The features also are economically feasible and environmentally sound for this location.

To further the discussion, how can the development community be motivated to utilize these practices? As previously noted, the development business is complicated, time-consuming and risky. Even the most enlightened development plan represents a tremendous alteration to the land and the function of natural systems. Neither impacts nor the building of places for human beings can be eliminated.

Developer Buddy Milliken believes there must be a convergence of environmental, social and financial value in every aspect of our developments. "As a community, we need to find ways to do it that make sense financially and not depend solely on moral pleas. There is not enough altruism to get the job done. This is the question. There will be a perpetual need to answer it," Milliken says.

For additional information and details regarding uniform development ordinance variations that were required to accommodate several unique components of Woodsong, visit the project Web site at *www.villageofwoodsong.com.*

Also, The Center for Watershed Protection offers an online worksheet to assess whether local ordinances support sustainable development (*www.cwp.org/pubs*).

Chapter 4: Designing Individual Parcels

The design, development and management of individual parcels of land for residences, shops or offices can significantly affect the quality of water in below-ground aquifers as well as surface water, including rivers, streams, lakes, ponds and wetlands. Each parcel located within a watershed makes a contribution — good or bad.

INTRODUCTION

Design and land development practices can help protect water resources. This chapter will discuss techniques individuals may use to maintain and improve the effects of parcel developments and help protect the quality of the estuarine environment.

These practices collectively fall under the term "water quality landscaping." An individual with a bit of research and a dose of informal engineering, coupled with intuition and guided by a personal concern for the environment, can make a difference. Water quality landscaping seeks to work with ecological functions on the individual parcel level. Thus, while improving water quality, individuals and communities also benefit from the natural beauty that results from their landscaping efforts.

LEARNING FROM THE PAST

Knowing what the parcel or lot was like in the past and the processes that shaped the landscape can help property owners and designers interpret those elements and functions that have been preserved or can be renewed.

North Carolina's coastal plain, which extends from the piedmont fall line to the Atlantic Ocean, is up to 150 miles wide, with elevations up to 500 feet. Due to a slope gradient, its rivers and streams are broad and meandering. They flow through soils that may be peat-rich or sandy. All coastal landscapes have a role to play in sustaining clean, healthy waters. Sandy soils filter rainwater to recharge freshwater aquifers. Pocosin systems, which often appear dry, are the source of water for many coastal streams. The landforms of the coastal plain resulted from thousands of years of wind, rain, floods and drought, as well as erosion, sea-level changes and other interrelated processes. There may be many small and unique communities of plants and animals within the wetlands, rivers, forests and open land.

Stanley Riggs' guidebook in this series, *Shoreline Erosion in North Carolina Estuaries,* provides greater detail on the geologic structure and history of the coastal plain. Riggs discusses coastal plain geomorphology and the region's primary habitat types. Within these large groups are many fascinating microcommunities, with each responding to microscale change in the soils, water, exposure, topography and elevation that comprise the environmental context.

SITE ANALYSIS PROCEDURE

Analytical sketches of the parcel dimensions and environmental conditions will assist in developing a good design to reduce runoff and increase infiltration of rain water. The first step is to develop a working base map of the parcel. The second step is to develop a series of sketches that illustrate soil type, plants, views, wildlife habitat and sun/shade exposures. Overlaying these elements provides a composite perspective of site conditions. The third step is to create a landscape design based on this information.

A designer can create a sustainable site plan that works for the property owner and the environment.

BASE MAPS

To work with the land in a sustainable manner requires knowing how the site fits into the larger watershed context and how the site functions on a hydrologic level. This requires becoming intimately familiar with the landscape. The best way to do this is to develop a series of analytical maps of the existing conditions and processes that affect the parcel.

Begin with a base map or a bird's eye view of the parcel that shows each feature, its orientation and relationship to the environment. A base map may include some or all of these items (**Figure 20**):

- North arrow
- Property boundaries
- Footprint of all structures and built features
- Existing vegetation and soil types
- Easements, setbacks, utilities such as phone, fuel, electricity, cable
- Elevation changes, topography, slopes
- Points of access or entry
- Patios, sidewalks, driveways and paved areas
- Context, including adjacent and surrounding uses
- Infrastructure (septic, sewer, water lines, wells, fuel tanks)

A licensed surveyor can help create the most accurate base map, but most property owners can handle the task alone.

To create a sketch version of a base map, begin with the tax map of the property. The tax map should have dimensions of property lines, utility easements and set backs, as well as the location of any taxable structures on the property at the time the map was created. This map also should have the North direction noted. Transfer this information to graph paper, then using the grid on the graph paper as a scale, measure and add the other important features.

SITE ANALYSIS

A series of analytical maps and annotated notes should be developed to include information about the following site features and processes:

- exposures, including sun and wind patterns
- waterways, hydrology and drainage patterns
- soil conditions and characteristics

Context

Using a U.S. Geological Survey topographic map, find the site within the watershed. Delineate the watershed and sub-basin. Is the site in the headwaters or near the outlet of the sub-basin? Landscape position is important. Generally speaking, in the headwaters area, a site would be in the uplands and thus, the water table would be lower. Appropriate techniques would be ones that infiltrate water. On the other hand, in lower land near the outlet, the best techniques would be wetland options that spread water out, retaining and storing it.

BASE MAP

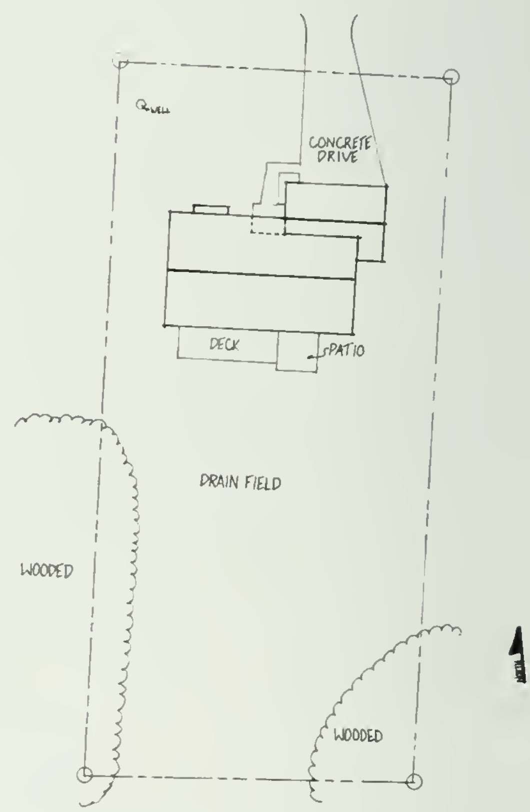


Figure 20: Site Base Map. *Base map should locate all important features existing on the site.*

Call the local planning office to determine if any government regulations affect the use of the property. If the parcel is adjacent to a body of water in the coastal region, it would fall under the state's Coastal Area Management Act requirements and basinwide stormwater management regulations. Generally speaking, any plans to grade, fill, dig or change the flow of water will be regulated within the coastal zone. Minimally, most lots have a setback requirement for hard structures.

Also, identify on the base map major

activities that occur on adjacent properties. Aesthetically, are there areas that require more privacy? What is the general appearanee and tone of the neighborhood and town? What views should be enhanced, preserved or hidden? Sketch any of these observations on the site map.

Soil

Knowledge of soil conditions and characteristics is *very* important. Review a copy of the county soil survey at the closest U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS) office or from the county Cooperative Extension Service office. The soil survey will provide information on many soil factors, not just the topsoil. These include depth to the water table, infiltration rate, slopes, engineering suitability for buildings, septic, etc.

The soil horizons may have been altered during the grading process. Take several soil samples, which can be analyzed by the N.C. Department of Agriculture. The samples will help determine soil structure, nutrient content and pH. The landscape could be sandy, have high pH, be well-drained and have a low water table. Or, it could be sandy with a subsoil clay layer that holds the surficial water table within 18 inches to 2 feet. Knowledge of such factors is necessary to determine the most appropriate techniques to use in the design.

Plant Community/Land Cover

Plant communities are indicators of topographic, soil and hydrologic patterns of the land. Knowledge of them can provide critical information about land cover patterns and landscape functions. However, remember that the current generation is not the first to alter this landscape. The East Coast landscape has been drastically altered many times in the past 300 years. Farming and forestry activities involved extensive removal of native plant material, and often involved severe ditching, draining, filling, and in some cases, very sophisticated water management. The plant material on a given parcel may not be native to the coastal zone.

Some landscape changes occurred before modern, computerized recordkeeping, so knowledge of historic land cover may require use of archival material. One source is the local or state library archives that may include historic aerial photographs, maps and written documentation. The N.C. Department of Agriculture has archival photography of farmland. The N.C. Department of Transportation has maps, photos and files of transportation corridors. (*The NCDOT aerial photography that dates from the 1920s is an incredible resource.)* An expert such as an ecologist, botanist or soil scientist can give specific insight. Individual NRCS and Cooperative Extension agents may be very knowledgeable about past land-use activities. Local community college faculty members in the botany or ecology departments may be other excellent sources. They may have conducted studies of the indigenous landscape, and thus could provide a wealth of information not only on the plant communities, but also the function of plants within the landscape.

Such information will provide guidelines and context for the design. Incorporate this information with current conditions in the landscape. Property owners with lots that are often wet may find that the parcel was once a pocosin, and as such, it would be a good place for a wetland garden.

Hydrology

To understand the hydrologic processes, go outside while it is raining. Watch where the water flows. Note where the water puddles, erodes or infiltrates the soil. Note the patterns on the site hydrology map. Use bigger arrows for larger flows, etc. Drive around the watershed above and below the site, and using directional arrows, note areas where water flows to and off the site (**Figure 21**).

Note ditches, creeks, streams or drainage ways running through or along the property. These areas should be buffered with plant material to create streamside habitat for aquatic organisms that may help clean the water. Plants also provide shade, stabilize the banks and clean water that runs along the edges. The greater the width of the buffer, the better

protection it can provide to the creek. Native plant material, including a mix of trees, shrubs and herbaceous materials will provide water treatment as well as habitat niches for wildlife.

Noting the location of drainpipes or gutters, indicate flow direction and discharge location. An objective of the landscape design will be to "disconnect" water flowing directly from hard surfaces to stormdrains and streams. Instead the water may be collected and retained so that it may infiltrate into the aquifer. Areas where water naturally collects will be good spots to collect stormwater on site by installing cultivated wetlands or rain gardens.

Seasonal Sun Patterns and Shading

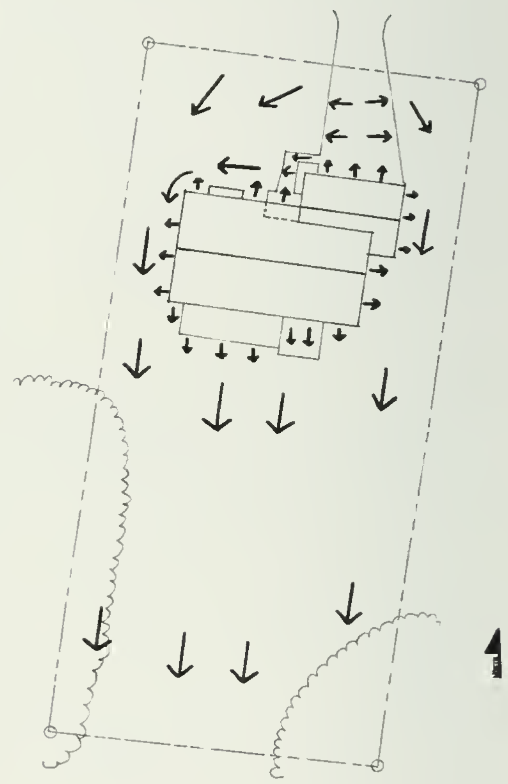
Structures and vegetation change sun and wind patterns. These patterns are important because they create many small microclimates in the site (**Figure 22**). Seasonal differences in these patterns can be quite extreme — even northern exposures in the summer can be very hot. Note shade and hotspots created on and off site relative to structures and other vertical elements, including trees. This will affect plant selection and uses within the site.

Passive solar experts recommend evergreens on the north side and deciduous trees on the south side to maximize the use of the sun's energy in winter and minimize the effects of heating in the summer while gaining a winter wind break from potentially damaging Nor'easters on the coast.

Vegetation

Evaluation of site vegetation should include type, size, location, condition of the plant material, and an analysis of plant associations, such as plants that occur together. Using books devoted to native plants and local plant communities will be very useful. For example, many volunteers in the Cooperative Extension "master gardener" program use North Carolina Sea Grant's popular *Seacoast Plants of the Carolinas.* Review and develop a list of plants indigenous to the site's habitat category, as well as compatible, noninvasive horticultural cultivars to supplement the native material. Avoid invasive non-native species and those requiring extensive irrigation, pesticides and fertilizers. Nursery owners, landscape contractors, landscape architects, Cooperative Extension horticulture agents, master gardeners and local community college botanists are good resources regarding local flora.

DRAINAGE PATTERNS



EXPOSURES (sun & wind)

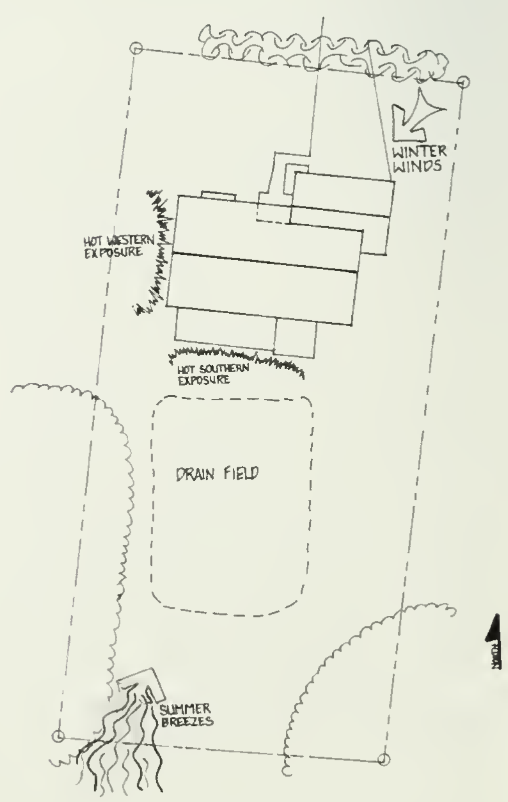


Figure 21, top right: Drainage Patterns. *Directions of water flow, collection and dispersion help to know where to put compatible design features.* ***Figure 22, bottom right: Sun/Wind Exposures.*** *Sun and wind create many small but significant microclimates that can affect plant and water relationships on site.*

DESIGN PROGRAM ANALYSIS

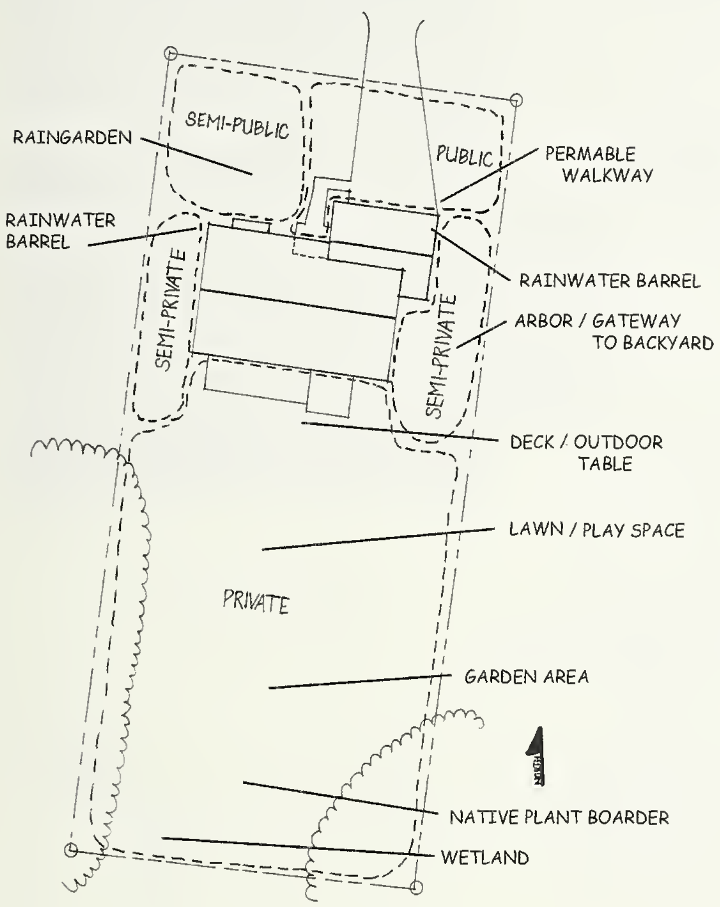


Figure 23: Design Program Analysis. *An analysis of user needs is an important part of the design process. This information is used to match needs with site conditions and processes.*

Wildlife

A wildlife corridor is a route along which animals move to feed, breed and migrate. These segments of land need to be connected in order to maintain habitat critical to support wildlife. Riparian belts along rivers and streams, where species migrate and commingle, are especially important corridors. Information on existing wildlife, ranges or corridors, and habitat needs is extremely important. Property owners often have the opportunity to create and maintain wildlife habitat on the site. Wildlife plays an important role in a healthy, functioning ecosystem, and thus it is important to provide the right habitats and corridors. Contact the N.C. Wildlife Resources Commission or U.S. Fish and Wildlife Service for more information.

Views

"Viewshed" analysis, while not an ecological factor, is essential to the aesthetics of the design. Some views may be emphasized. Others may require screening with plants, trees or even fences. Check the views from a variety of locations both on and off site, inside the buildings and out.

For example, if a neighbor has a particularly attractive specimen tree, frame that view. Properties bordering waterways may have views ready for "framing." However, such design strategies should not destroy critical riparian fringe vegetation. Removing such vegetation to enhance a view of the water is not recommended. Choose low, native grasses and deciduous, tall-canopied trees to frame and maintain a view.

LANDSCAPE DESIGN DEVELOPMENT

The next step is to integrate the base map with site assessments to develop a landscape design program that is wedded to site functions.

Programming

Make a list of all the activities anticipated within the parcel or lot. Group the activities into private, public or service functions. Place tracing paper or a transparency over the base map and draw bubbles around areas on the site that would be suitable for these activities, list the activities that would occur on that area inside the bubble. Pay particular attention to movement in and out to various locations and for various activities, such as play areas, cookout locations, gates, doors, cars and bicycles (**Figure 23**). This will allow synthesis of the user needs within the assessment diagrams.

Design Synthesis

This guidebook cannot communicate all the subtleties of landscape design, which is a complicated blend of art and science. For some parcels, a professional designer may be needed. In those cases, the property owners should look for a

landscape architect with experience in native and restoration design. But for many lots, the property owner may create the design, sometimes as a project for a class at a local community college. A third option would be to establish a consulting relationship with a landscape architect who can review plans and provide input. In all cases, the property owner likely will want to consult books on design techniques, such as those listed in the resource section of this guide. Of particular interest may be the approach for design synthesis highlighted by Ian McHarg in *Design with Nature*.

Using the various overlays that identify soils and slopes, hydrology and vegetation, look for opportunities to work with the existing site to meet the new needs. Pay particular attention to the flow of water across the site and how it may be incorporated into the design elements. For example, plant a rain garden in a low area that collects water. Plan a xeriscape — a landscape technique used in arid climates — for a dry hill. Also, review for activities that may conflict. A patio would be inappropriate on a steep slope or in a wet drainage area.

Continue to iteratively refine the design program, looking for complementary relationships between the programmatic needs and site functions.

Best management practices (BMPs) can increase the coastal ecological aesthetics of the landscape by reducing use conflicts, mitigating impacts, and enhancing overall hydrologic functions of the parcel.

Following are a variety of techniques to enhance the sustainability of the design.

Porous Pavement

Use of porous pavement can reduce velocity and volume of stormwater runoff. The increased roughness of the material slows down the water and porosity increases infiltration through the paving itself. This treatment is particularly effective in the coastal zone (**Figure 24**). Properly sited, installed and used, permeable paving is no more expensive to maintain than other surfaces.

Alternative materials to standard concrete or asphalt for driveways or sidewalks include porous asphalt or porous concrete. Gravel, permeable stone pavers, precast cobblestones, brick and paver-lock stones are also good alternatives. All porous paving materials require careful installation and maintenance. An aggregate must underlay most materials to act as a reservoir until rainwater can percolate into the soil or drain slowly away. To be effective, a regular maintenance program is required to remove any silt or sediment source from the surface to keep the pores from becoming clogged. These materials are not well suited for heavy traffic areas, such as truck or service access. Reference material can provide specifications for installation and uses, and a licensed landscape contractor can provide assistance on the design, construction details, costs and installation.

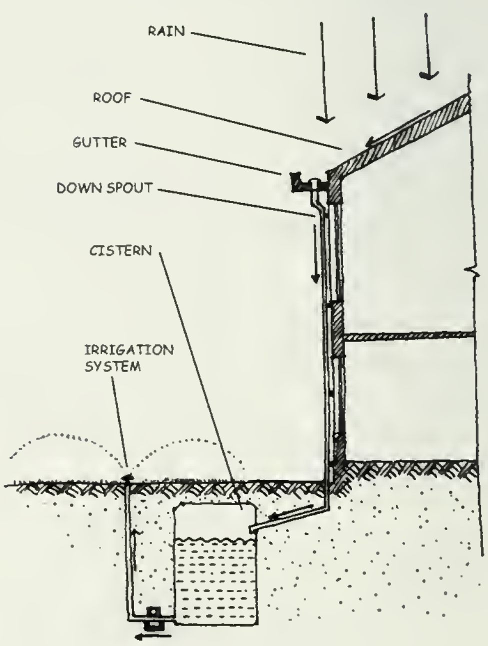


Figure 24, top: Example of Porous Paving. *Porous paving can be used for driveways, walks, patios, and parking — it can be beautiful and help slow down water and increase infiltration.* ***Figure 25, bottom: Cistern Diagram.*** *A cistern for collecting rainwater can be installed below ground.*

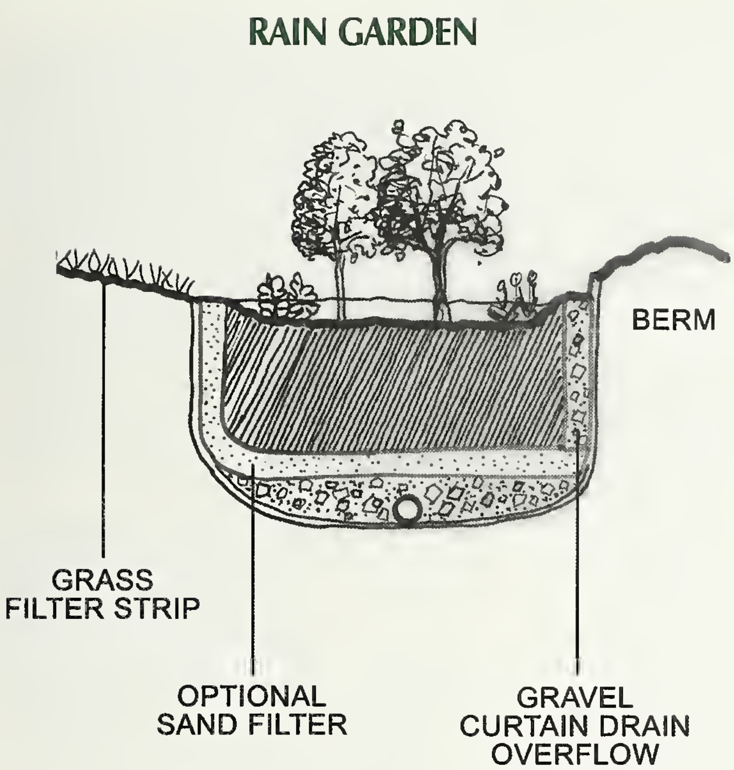


Figure 26: Rain Gardens. *Rain gardens or bioretention areas can be stand alone systems or integrated with a storm water management system for the site. Either way, they are beautiful opportunities to treat and manage stormwater.*

Rainwater Harvesting

Rainwater harvesting is the process of collecting rainwater, then reusing it for nonpotable uses such as irrigating, washing cars, flushing toilets, etc. Collection and use of rainwater on a site has multiple environmental benefits. It reduces stormwater and provides opportunities for reinfiltration, but *most importantly*, it reduces the use of potable water supplied from groundwater or from municipal sources for nonpotable applications.

Harvesting can be as simple as placing a barrel under the downspout. Many people use a hose and gravity flow to dispense water through a soaker hose to irrigate the garden. Rainwater collection can also be very sophisticated and an integral part of a building's infrastructure. Large tanks can be stored underground or in aesthetically pleasing systems that can be incorporated into the overall design. The water can be cleaned with sophisticated filters, then dispensed using pumps and pressure tanks (**Figure 25**).

Rain Gardens

Bioretention systems, also known as rain gardens, are aesthetically pleasing biological systems that can be used to manage and treat stormwater by holding and infiltrating the water through a designed system of soils and plants. Rain gardens are typically designed to allow complete infiltration of stormwater within 24 hours. Therefore, plants used in a rain garden must be adapted to having their "feet wet" but also be tolerant of dry periods.

Like rainwater collection systems, bioretention areas can be simple and freestanding or integrated with other components of the site's stormwater infrastructure. However, all bioretention systems include the same basic components — pretreatment filter strip of grass, shallow surfacewater ponding area, planting area, soil infiltration zone, underdrain system, and overflow outlet structure. All these features work together to provide infiltration, retention and treatment of stormwater.

To collect the water, the surrounding landscape, roads and walks must be graded to drain towards the garden. Swales can be directed to empty into the garden, and cuts can be installed in curbs at strategic points to drain water off surfaces and into the bioretention area (**Figure 26**).

The volume of water draining to the garden site determines the size of the bioretention area, so picking a location is very important. First, an important component of rain garden design is to facilitate water drainage into the soil because this is how the stormwater is cleansed. Since the water table is so shallow on the coast, the location and design size need to be above the groundwater table. Secondly, to minimize mosquito populations, the water should drain away within 24 hours. Once the system matures with habitat for birds, frogs and lizards, this becomes less of an issue.

Parking lots and driveways are excellent locations for rain gardens nad

bioretention areas. An easy, effective way to collect, filter and treat stormwater in a parking lot is to invert landscape islands and use them as bioretention areas (**Figure 27**). This is an often overlooked, yet easy to design and implement, mitigation strategy.

Small rain garden systems, integrated with multifaceted program to manage stormwater, are a good approach for managing and treating stormwater on small sites in the coastal zone. For more information, see the fact sheet, *Urban Waterways: Designing Rain Gardens*. This fact sheet was developed to assist in the design of these systems. It can be found online at *www.bae.ncsu.edu/programs/extension/*.

Dry Wells

A dry well is a small, excavated pit or trench backfilled with aggregate used to infiltrate surface water into the ground. These systems are very simple but can provide filtering, absorption, trapping, and some biological treatment in areas too tight for other treatments. As with rain gardens, it is important that the drainage from the surrounding area or surface be directed towards the device. These are very effective when used below patios, at the end of roof gutters, or along the length of drainage swales. On the coast, these systems should be designed to be shallow and wide in order to stay above the groundwater table. These systems require active maintenance.

PARKING ISLAND BIORETENTION SYSTEM

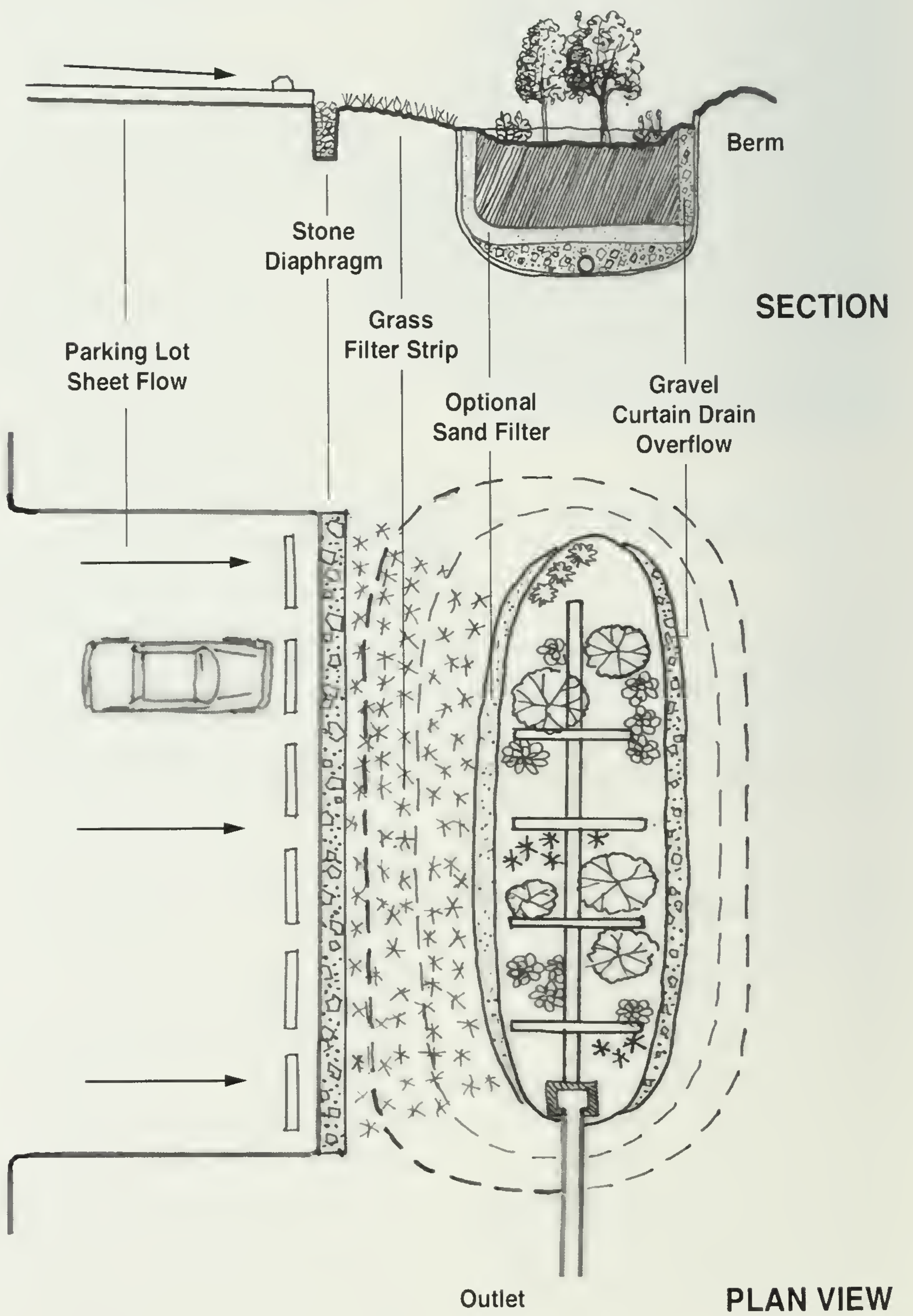


Figure 27: Parking Islands as Bioretention Areas. *Islands in parking lots as well as other communal areas make excellent sites for bioretention areas.*

Top: *Bioretention areas add an aesthetic touch to stark parking lots, while effectively filtering stormwater.*
Bottom: *A constructed wetland or raingarden filters water through a designed system of soils and plants.*

NOTE: *The next three techniques — level spreaders, vegetated swales and filter strips — involve spreading water out along a vegetated gradient to slow down the water and allow it to infiltrate. They are used for larger development projects but can be very useful on a lot-scale project. For more information, see the* Design of Stormwater Infiltration Systems *by The Center for Watershed Protection.*

Level Spreader

A level spreader is a landscape feature used to convert concentrated, erosive runoff into a dispersed, sheet-flow pattern. Spreading water across a vegetated slope slows water flow velocity, which increases infiltration and reduces erosion. Level spreaders can be used as the pretreatment lawn strip to carry runoff from a driveway or patio to a bioretention facility. The receiving area of the outlet should be uniformly sloped, not susceptible to erosion and well vegetated. This will increase infiltration, retention and time of concentration.

Filter Strips

A critical consideration in designing a natural drainage plan is to identify opportunities to disperse runoff from impervious surfaces — rooftops, streets and parking lots — onto the pervious, vegetated areas of the site. These vegetated areas, or filter strips, allow runoff to infiltrate into the ground. Runoff is directed in several ways. It can be conveyed from rooftops via downspouts. From roads, driveways or parking lots, runoff is directed to filter strips as sheet flow or through slotted curbs.

Healthy vegetation could minimize erosion and improve the filtering of pollutants. Where high concentrations of salt are expected, salt-tolerant vegetation should be planted. Pasture vegetation or grasses native to the North Carolina coastal zone are ideal in most filter strip applications. Remember to choose salt-tolerant species where necessary. Deep root zones and extensive biomass give native grasses performance advantages over lawn-type, turf grass. Forested filter strips also can be effective because of their ability to take up certain pollutants from the root zone and store them in their biomass. These are best when used on a

microscale and integrated with other treatment practices, but also can be used as large single-shot treatment systems.

Vegetated Swales

Swales function much like filter strips except that their purpose is to convey concentrated flow. Unlike paved street gutters, swales are vegetated and move water more slowly allowing a portion of the runoff to infiltrate into the ground. Swales are suitable alternatives to paved street gutters for many types of development, particularly where the number of driveway crossings is not large. Swales are implemented easily on a rolling to gently rolling topography that is common in coastal areas. Where feasible, runoff should be routed from swales to level spreaders, rain gardens or dry wells — but never directly to surface waters.

Constructed Wetlands

Constructed wetlands store water, reduce peak flow rates, remove runoff contaminants, and provide excellent habitat. The use of native plants enhances these functions as well as the removal of stormwater pollutants, improves aesthetic appearance, and reduces maintenance needs (**Figure 28**).

There are two recommended types of constructed wetlands. A single large, shallow, wet bottom basin has a large, deep permanent pool, akin to a Carolina Bay. The second type is a micropool wetland basin that contains smaller deep pools near the outlet and/or inlets. The remainder of the basin bottom, which either has very shallow ponding or is dry between storm events, is vegetated primarily with wetland plants, sometimes in combination with prairie vegetation or turf grass.

The basic philosophy of constructed wetland designs is to replicate the components of natural lake and wetland systems. The following design considerations are important.

Shoreline slopes of open water areas should be relatively flat.

Shoreline zones and frequently flooded areas should be planted with native wetland vegetation. Where feasible, side slopes should be vegetated with savanna grasses and small shrubs.

Basin shapes and open water contours should be irregular to enhance appearance.

CONSTRUCTED WETLAND PLAN

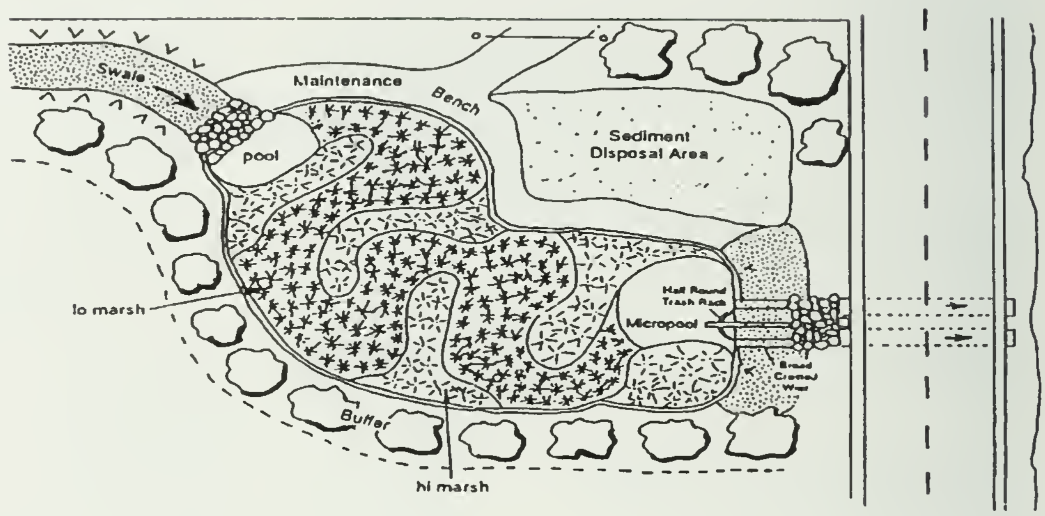


Figure 28: Constructed Wetlands. *Constructed wetlands are useful for areas that are typically wet to store and retain water. These ecosystems do not increase mosquito populations because they also attract birds, frogs, lizards and other creatures that enjoy mosquitoes as a meal.*

Use of Native Plants and Noninvasive Cultivars

The traditional green grass lawn has been borrowed from the heavily grazed, short grass pastures and formal gardens of Europe, particularly England. In that moist climate, the closely cropped grasses evolved with the grazing sheep, goats and cows. Pioneers from Europe brought the short grasses, as well as medicinal and food plants, to make the unfamiliar New World feel familiar and homelike.

Unfortunately, the grasses they brought do not thrive without a great deal of effort to simulate the conditions under which they evolved in Europe. This region of the country, with its harsher climate of extremes of heat and deep freezes, drought and drenching rains, is an inhospitable atmosphere for short-

cropped, short-rooted grass. Therefore, the contemporary weed-free lawn is maintained at a high price (nutrients, pesticides and lots of water), not only in terms of dollars, but also degraded water and air quality and water consumption.

Many areas within a lot can be renewed with the use of native plants and well-adapted cultivars. In returning to a more natural landscape, property owners chose plants that require less maintenance and coddling, while providing environmental, economic and aesthetic benefits. The ecological history of the site will help in the selection of native plants most appropriate to the given soil type and saturation conditions.

Poorly drained areas of the site can be planted with species that can tolerate standing water or saturated soils. If these areas are also in a low area of the site, they may be designed for water to drain internally, such as placement of a dry well to encourage infiltration rather than surface runoff. Dry or well-drained locations can be planted with species tolerant of dry conditions in order to minimize the need for irrigation. This landscape strategy helps minimize water usage and runoff.

Designing, installing and managing restorative landscaping projects will vary in complexity and approach depending upon the nature of the site and the project goals. There are different degrees of natural landscaping, ranging from a small native flower patch to a full-scale replication of a plant community covering many acres.

Green Building

If the project includes building new structures on the property, site development or renovation, review "Green Building" guidelines for techniques that can reduce existing environmental impacts. At a minimum, locate all buildings, homes, sheds, garages, etc., on as small a portion of the property as possible. This approach reduces the total impervious area and minimizes the area that must be cleared and graded to accommodate and access the structures.

For example, avoid locating structures on soils with high infiltration rates or in stream buffers, wet areas, steep slopes or near water. Have the contractor use the smallest equipment possible to accomplish the grading. Expand tree protection zones to include entire plant community associations and extend beyond the drip line of the outermost plants.

During the construction phase, be sure to minimize areas where materials are stored and on which heavy vehicles may move. This also minimizes the area of soil compaction on the site. Collect rainwater. Recycle used or "grey" water where appropriate. Use recycled material. Reuse and recycle construction materials from the site. For more information visit the various Web sites available on Green Building.

CONCLUSIONS

Sometimes individuals question the overall impact of their actions regarding small lots or parcels. But, in fact, one person and one site can make a tremendous difference in affecting the quality of water. The stormwater runoff that is generated from an individual site or parcel can be treated easily and aethetically by using a number of techniques, such as constructed wetlands, bioretention areas or vegetated swales. A volume-control technique, such as rainwater harvesting, may be employed. Using collected rainwater in place of potable water for irrigation, saves money.

As more parcels reflect sustainable practices, the positive impacts will be greater on the watershed as a whole. The watershed comprises many small sites, each making a different contribution to estuarine water quality. Sustainable design practices can help protect priceless coastal resources. Thus, design, development and management of individual pieces of the landscape are extremely important not only to the individual, but also to the entire community.

Chapter 5: A Residential Parcel: An Individual Case Study

This case study presents the site analysis and design for a typical suburban lot within the coastal zone. Although the case study focuses on the details of a specific lot, the process would be similar for any single parcel within the landscape. The design of an individual parcel or lot impacts the water quality within that watershed — for better or for worse. The steps outlined here could be taken by the landowner alone or in concert with landscape design professionals.

INTRODUCTION

In this case study, the site is a half-acre lot, located in North Carolina's coastal plain. The parcel is in Carteret County, one of the 20 counties included in the Coastal Area Management Act. The property includes a 1,300-square foot ranch home built in the 1990s. The lot is located about 200 yards from Bogue Sound and is about 160 feet from the nearest tidal creek. The parcel originally was part of a bottomland hardwood forest.

SITE ANALYSIS

Fall is the best time for planting most material. When considering any type of renovation, the process should begin at least a year in advance. Additionally, it is best to observe the landscape for at least a year before making any modifications.

A landscape plan begins with knowledge of the historical context of not only the specific lot, but also the larger area or region. This lot, which includes an existing house, is located in a small development that had been a farm field prior to 1964. This development doesn't have a common sewage or water system. The lot backs up to a wetter zone that is comprised of bottomland hardwood forest. With a little investigation, the homeowner found that the land had been farmed for about 15 years. From the U.S. Geological Survey topographic map available at the local county offices, she learned that the lot was in the middle of a slight slope, neither in the headwaters, nor in the bottom of the watershed.

DEVELOPING A BASE MAP

The parcel had been surveyed when the current property owner purchased the house, but that survey only showed the boundaries of the property. A tax map showed the house footprint, driveway and setbacks, which she added to the base map. The homeowner is responsible for maintaining a road easement at the front of the property, and thus needed to incorporate the easement into the landscape plan. The patio and deck did not appear on either the survey or the tax map, so she measured each and added the dimensions to the base map.

This homeowner integrated the natural attributes of the lot to create a landscape design that is aesthetically and environmentally appealing.

The drinking water well and approximate location of the septic system's drainfield were the next additions to the map. The homeowner didn't know the exact area of the drainfield, and called the county Health Department to verify the location of the drain field. The electric and phone lines, which enter the house from a pole, were marked on the base map so that trees and tall shrubs would not be planned for those areas. The homeowner also contacted the gas company to locate the gas line. Some locations have utilities underground. All utility lines or cables must be clearly located before any landscape or construction project begins. The last item on the "base map" was the location of the existing wooded area, as this spot would remain wooded to connect to existing woods for habitat and linkage. This also helped to provide privacy and define the edges of the back yard (**Figure 29**).

SITE ANALYSIS MAPS

Site analysis maps show how the site functions — before and after changes. These maps — developed from data gathering as well as from direct observation in the yard — allowed the homeowner to clearly see the different processes at work within the landscape.

To begin, the homeowner traced the base map's house, lot lines, driveway and drain field onto several blank pages of transparent material, either tracing paper or a transparency. Then she took the site analysis maps outside during different times of day, noting different conditions, or microclimates, on the site. The transparent paper allows her to layer different sets of information on top of her base map. It would be difficult to read and identify spaces for design if all the information is on a single map. On a transparency, the homeowner noted the hot sunny spots, cold winter spots, summer breezes, and the notable views. She indicated all the places that had different temperatures, water flow and erosion. She also noted how far the shadows stretch into the yard at different times of the year (**Figure 30**).

Then, during and after rainstorms, the homeowner walked around the parcel to note how the water moves across her relatively flat yard. By watching the drainage of the yard, she determined that the lot sloped from front to back, with the house on a raised area. The driveway drained from the centerline out into the yard. However, water gathered and puddled in several places. With assistance from the county Cooperative Extension agent, soil samples were gathered with a post-hole digger and sent to the N.C. Department of Agriculture for analysis. The report revealed the soil is a sandy loam, with very low nutrient content, with some ribbons of clay. Its fairly uniform nature may be due to the farming history of the site or earlier landscaping (**Figure 31**).

Because the back yard ends in woods, the homeowner has an opportunity to watch deer graze on hosta plants. She also sees raccoons and other small wildlife, including birds and some rather large bugs. Because she enjoys having the wildlife on her lot, this homeowner wanted to provide more wildlife habitat in her landscape plan.

The last analysis map or transparency identified private spaces and those exposed to the neighbors — a distinction that often is overlooked in a landscape plan. This homeowner defined her back yard as private space, while the front yard, especially near the driveway, as more public. The opposite side of the front yard and the side yards were identified as transition spaces.

UTILITY LOCATIONS

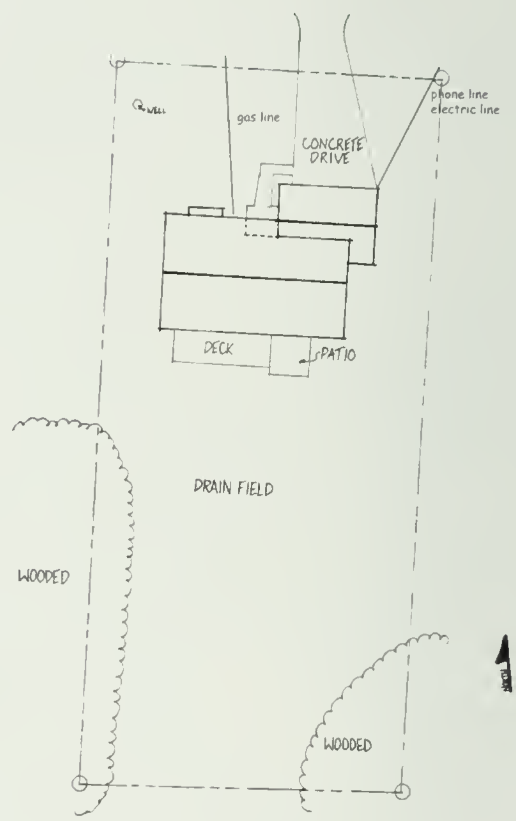
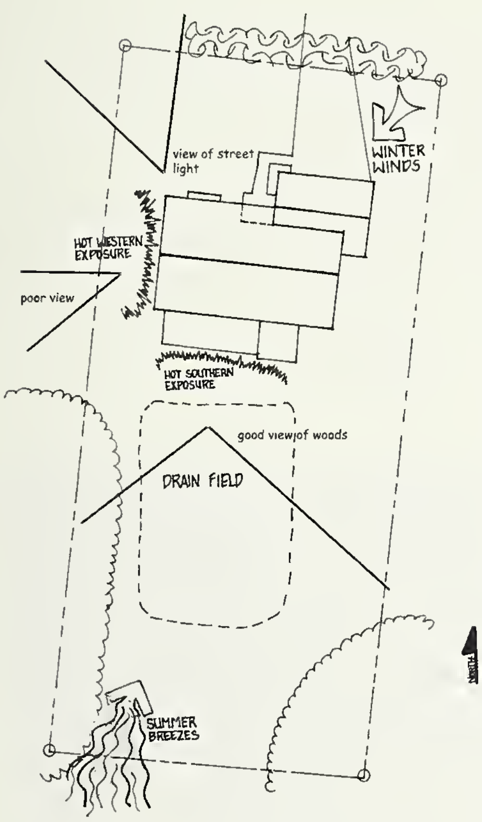
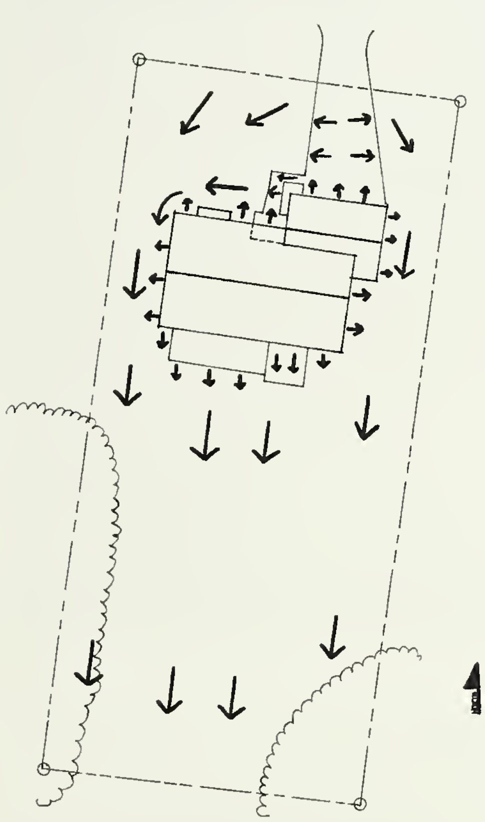


Figure 29: Utility Locations. *All utility lines and cables must be located before any project can begin.*

SITE ANALYSIS



DRAINAGE PATTERNS



DESIGN PROGRAM

To develop a design program, the homeowner began by compiling a list of all the activities she desired in the yard. She overlaid each transparency over the base map in order to match the activities to specific spaces in the landscape. Sometimes the match was obvious — sometimes not. She approached the task with the understanding that some spots within her landscape will take a few seasons to resolve, while some will always be evolving. A solution for a "trouble spot" may become clear once the space around it has changed (**Figure 32**).

The next step was plant research. The homeowner hit the nurseries to talk with experts. She also purchased several books on landscaping with native coastal plants. She developed a list of available plants that would work within the microclimates of her property. She then made a list of different plants, with a focus on those that work within communities — groundcovers, shrubs, trees — each with seasonal features for year-round interest. Plant communities are defined in layers, starting with canopy trees, moving down to understory trees, shrubs, vines, and the herbaceous layer of plants, such as ferns and flowers.

The homeowner categorized her list, designating those plants that could tolerate shade and sun, and those plants that grow together in natural communities in the bottomland hardwood forest. Cooperative Extension agents and nursery and landscape professionals helped her determine which plants would thrive within specific lot conditions. A small consulting fee with a professional can be both helpful and cost effective.

GENERATING A DESIGN

After the intensive study of the lot and available plant material, the homeowner was ready to begin. She looked first to best management practices (BMPs) within her means and applicable to her yard:

- rain water harvesting in barrels
- a wetland area in the back of the back yard
- porous walkways to the garden
- native plants or well-adapted cultivars

With the BMPs in mind, the homeowner integrated the design program with the site functions. She overlaid the analysis maps, first looking for spots where trees have room to grow, frame the house and landscape, and create shade where needed — deciduous trees to the south, evergreens to the north — to facilitate passive solar gain for her house. Trees, which are more expensive to acquire and require the longest time to develop, are critical vertical elements that create the "bones" of the design. The homeowner put them in first.

Figure 30, top: Site Analysis. *The homeowner noted how the site functions.*
Figure 31, bottom: Drainage Patterns. *Infiltration of soils can vary greatly, affecting the location of design elements..*

Views, hot spots around the house, the drainfield and the power line locations each provide clues to the most and least appropriate places for trees. In the front yard, the homeowner chose to plant a tree to reinforce a more private area opposite from the driveway. Trees planted on the edges of the back yard, close behind the house, were chosen to provide some shade and shield out views of the neighbors' back yards. A row of three bald cypress trees now span the lower, wetter area of the back yard.

The circulation patterns, or walkways, were next on her list. Hardscape is more expensive to install than small perennials and shrubs, but is difficult to put in afterwards. It should be done as early in the process as the budget allows — perhaps in the planting off-season.

For an informal effect, the homeowner chose a mix of gravel and flat rock for a path that goes from the front to the back yard. The material is less costly than her first choice of natural stone, and easier to install. With the savings, she built an arbor that serves as a gateway into the more private space in the back yard. The arbor also functions as a vertical element within the treeless side of the front yard.

Renovating the soil also was a priority. Though fairly expensive, it is a basic step upon which the rest of the landscape success depends. A landscaper delivered topsoil and compost to renovate places where topsoil had been scraped away. This added organic matter and improved infiltration. To spread out the cost of plants and necessary soil renovation, the lawn area was reduced in two phases. Once completed, the homeowner discovered an added saving by reducing the lawn — hours spent

DESIGN PROGRAM ANALYSIS

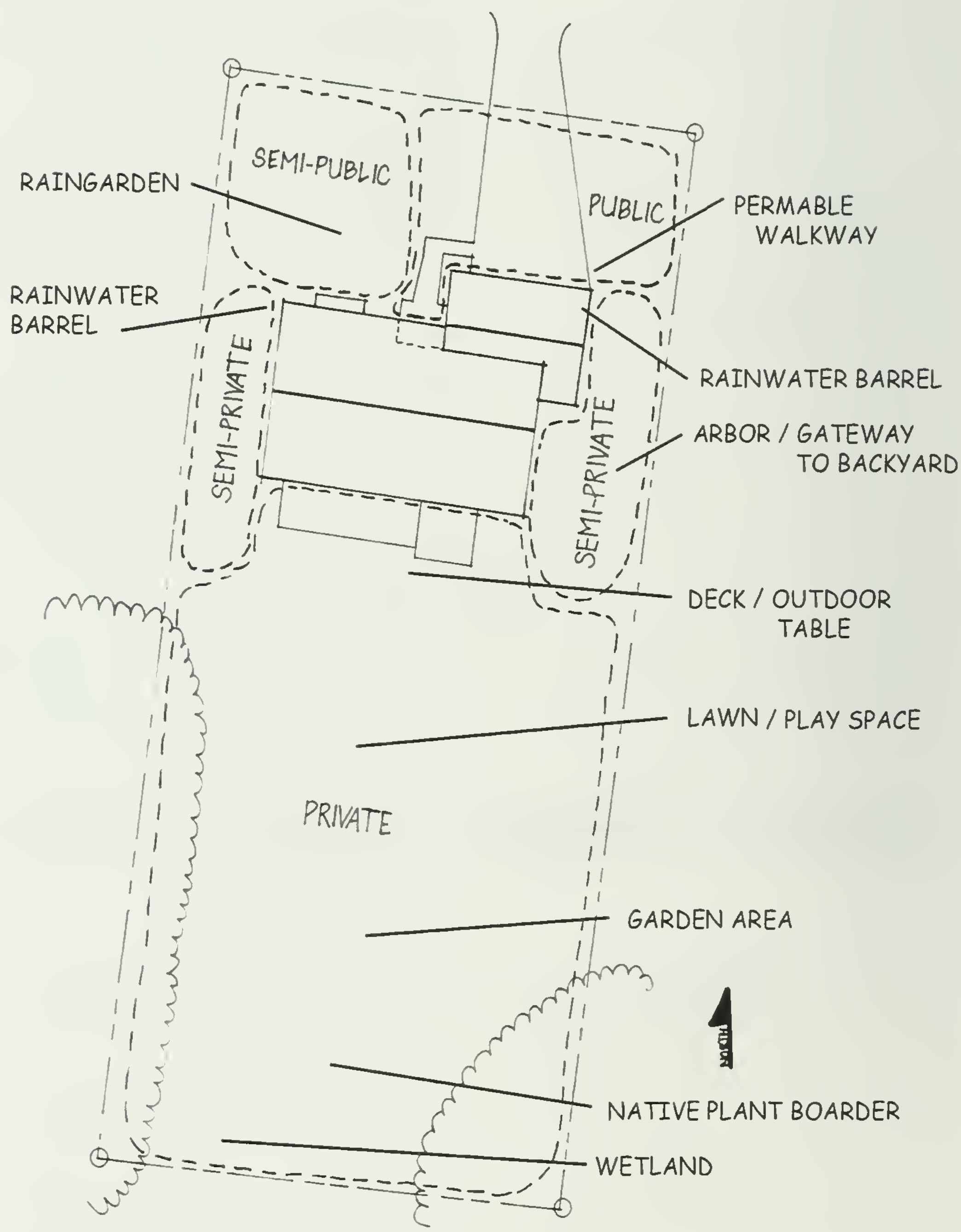


Figure 32: Design Program Analysis. The homeowner matched activites to specific spaces and sought appropriate plants and materials for each setting.

mowing the lawn with her gas-powered mower.

The BMPs chosen for the back yard included rain barrels and a wetland — inexpensive and easy to install. Rain barrels were placed under the existing downspouts and gutters. The barrels store a total of 180 gallons of rainwater — enough to water the back yard area during dry spells — and to keep the wetland wet to help sustain dependant wildlife. The wetland, located in the wettest spot in the back yard, required no grading or special treatments. Plants that like wetter conditions were selected for this space. The homeowner looked forward to hearing the frogs and seeing all the birds that would be attracted to the site.

Over time, the homeowner could select plant material from her list each season to add to prepared sites. The plants were selected based on the various microclimates. Taking her time allowed her to make design adjustments as she learned more about her yard and the many microclimates she created. She also continued to add to the complexity of the site, creating new habitats and seasonal effects.

When properly located, all the elements of a landscape design will work in harmony with the natural features and processes of the land.

CONCLUSIONS

The homeowner now enjoys her yard more, knowing that the benefits of the landscape changes go beyond water quality. She has witnessed a diversity of birds and animals that live in her yard. And, overall, the homeowner is gratified that she and her landscape are improving water quality within her watershed for no more costs or time than a traditional landscape. She also enjoys reduced maintenance time and costs since she used native plants and well-adapted cultivars that require very little effort to keep healthy and thriving.

Chapter 6: Special Focus: Planning for the Buffer

Shoreline or riparian buffers are corridors of native vegetation, which provide a natural transition zone between the upland development and the adjacent estuarine waters. Riparian buffers serve to filter runoff that can degrade estuarine water quality.

Suggestions highlighted in this chapter were adapted from Backyard Buffers for the South Carolina Low Country, *published by the S.C. Office of Ocean and Coastal Resources.*

The strategies, techniques and native planting materials mentioned should be considered by large-scale developers and individual homeowners to safeguard estuarine waters.

INTRODUCTION

Developers and individual property owners along estuarine shorelines can preserve or restore native shoreline planting while improving the environment and that of the adjacent waters. The use of landscaping techniques that focus on vegetative buffers may have the following *positive* effects:

- increase habitat for terrestrial wildlife and birds as well as certain aquatic/marine wildlife
- decrease the amount of stormwater runoff and possible sources of sedimentation and contamination
- increase the perspective that the home is part of the landscape, thus improving views from the home as well as those from the water
- increase property values, lower yard maintenance costs, and protect property from damaging storms

On the other hand, some developers or homeowners may fail to understand the effects of landscaping with lawn grass all the way to the water's edge or to the edge of any shoreline stabilization project, such as a vertical bulkhead. This type of landscape may have the following *negative* effects:

- increase stormwater runoff, which can carry excess fertilizers, sediments and pet waste directly into the waterways
- increase shoreline erosion
- increase the potential for flood damage
- decrease available habitat for wildlife
- reduce certain aspects of scenic natural views

Vegetative buffers provide the first line of defense for estuarine ecosystems.

A variety of native plants amd well-adapted cultivars provide a transition zone between upland development and wetland or estuarine waters.

Figure 33: Common Plant Recommendations for Riparian Buffers

Perennials/Low Plants	*Shrubs*	*Small Trees*	*Tall Trees*
• Butterfly weed	• Beauty berry	• Red buckeye	• Red maple
• Coreopsis	• Inkberry	• Eastern redbud	• Southern magnolia
• Swamp rose mallow	• Yaupon holly	• Dogwood	• Southern red oak
• Blue flag iris	• American holly	• Loblolly bay	• Live oak
• Black eyed Susan	• Wild azalea	• Red cedar	• Bald cypress
• Seaside goldenrod	• Sparkle berry	• Cherry laurel	• Willow oak

DESIGNING THE BUFFER

While still in the planning stage for a large-scale development or individual home site on an estuarine shoreline, it is important to minimize clearing near the water. The less land disturbance, the better. And, the smaller the building footprint, the better. Total landscape costs will be lower using native vegetation and well-adapted cultivars. Reducing lawn size will reduce long-term maintenance time and costs.

By emulating natural shoreline buffers, the view corridor from any structure to the water will be "framed." The use of low-growing native shrubs and grasses won't obstruct the view. If possible, keep the view corridor to about one-third of the total lot's width. Keep mature trees in the rest of the buffer area.

The depth of the buffer will vary with each landscape design. Estuarine shoreline regulations limit impervious surfaces — patios, drive ways, structures — within 75 feet of the high water line. The landscape design not only should enhance the environment, but also comply with North Carolina policy.

In general, the buffer design ranges from large to small plantings (**Figure 33**). Trees with their penetrating roots are left or planted closest to the shore. Behind them are shrubs, next native plants, then lawn closest to the home. Native plants and noninvasive, well-adapted cultivars might include flowering species which can attract butterflies and hummingbirds, those species with fall berries for migrating and resident birds, and dense shrubs for nests and ground homes for birds and small mammals. For low-lying lots with fringing marshes, a buffer of native shrubs, such as myrtle and cotton bush, might be considered.

Shoreline buffers improve the view from a home — and views of the home from the water.

BUFFER LANDSCAPE DESIGN HINTS

To reduce impact on the land, consider:

- using porous material for driveways and mulched paths to reduce runoff and increase water absorption
- massing plants into clusters to reduce sediment runoff
- increasing the diversity with a mix of trees, shrubs, ground covers and native grasses
- leaving some snags and even dead trees for bird perches and roost sites, if these do not threaten your structures

For planting recommendations, contact county Cooperative Extension offices and local nurseries. The New Hanover County Cooperative Extension Service (*www.co.new-hanover.nc.us/ces/cesmain.htm*) has an arboretum displaying native landscapes. The UNC-Chapel Hill Botanical Garden (*www.unc.edu/depts/ncbg/*) has a coastal plain section with examples of native plants.

Chapter 7: Resources

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ARTICLES

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ONLINE RESOURCES

North Carolina Agencies:

• *www.nccoastalmanagement.net*
Coastal regulations and information.

• *http://h2o.enr.state.nc.us/basinwide/index.html*
Watershed water quality information.

• *www.bae.ncsu.edu/programs/extension/*
Urban water quality information.

Coastal Plants:

• *www.uga.edu/~srel/bays.htm*
Carolina Bays Fact Sheet.

• *http://carolinasandhills.fws.gov/*
Carolina Sandhills National Wildlife Refuge.

• *www.em.robins.af.mil/conserve/natural/rbveg.htm*
Environmental Management Directorate, Robins Air Force Base. *Relict Upland Hardwood Bluff Forest Vegetation. Bottomland Hardwood Swamp Vegetation.*

• *http://arb.ncsu.edu/*
J. C. Raulston Arboretum NC State University. *Loblolly Bay: Exotic Floral Beauty in a True Southern Native.*

Open Space:

• *www.ctnc.org/*
The Conservation Trust of North Carolina, information on conservation organizations in North Carolina.

• *www.mdp.state.md.us/smartgrowth/smartwhat.htm*
Tax credit program to support open space initiatives.

Green Building:

• *www.tjcog.dst.nc.us/nccogs.htm*
Triangle J Council of Governments High Performance Building Guidelines as well as sustainable development case studies.

• *www.lowimpactdevelopment.org/mainhome.html*
Low-impact development guidelines.

• *www.113calhoun.org/*
South Carolina Sea Grant and Clemson University Center for Coastal Sustainability, information and case study.

• *www.usgbc.org/*
United States Council on Green Building, guidelines and details.

• *www.villageofwoodsong.com/*
Sustainable site design, exemplary stormwater management, walkable community.

Sustainable Design and Development:

• *www.cwp.org*
Center for Watershed Protection; information on ordinance development, development, open space and water quality protection guidelines.

• *www.sustainablenc.org/*
Sustainability guidelines and information for North Carolina.

• *www.soil.ncsu.edu/assist/*
Fact sheets on best practices for landscape management.

• *www.psu.edu/dept/cs/*
Center for Sustainability at Penn State University.

• *www.villageofwoodsong.com/*
Village of Woodsong, Brunswick County, N.C.

• *www.goprincegeorgescounty.com/*
Prince George's County, Md., Department of Environmental Resource Program.

Data Sources and Further Information:

• *www.nc-climate.ncsu.edu/*
Weather data, rain fall, temperature.

• *www.pewoceans.org/*
State of the Coast Report.

• *www.nccoast.org*
North Carolina Coastal Federation

• *www.ncsu.edu/seagrant*
North Carolina Sea Grant

• *www.design.ncsu.edu*
NC State University College of Design

• *www.nccoastalmanagement.net*
N.C. Division of Coastal Management

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NORTH CAROLINA SEA GRANT
NC State University • Box 8605 • Raleigh, NC 27695-8605
Telephone: 919/515-2454 • Fax: 919/515-7095
UNC-SG-01-13 • www.ncsu.edu/seagrant